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Residential Curbside Recycle Context Analysis

Ntchanang Mpafe

University of South Florida

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Residential Curbside Recycle Context Analysis

by

Ntchanang Mpafe

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Business Administration MUMA College of Business University of South Florida

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October 19, 2021

Keywords: Residential Recycle, Solid Waste Management, Pro-environmental Behaviors, Prompts, Sustainability, Contamination, Single stream.

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DEDICATION

I dedicate this thesis to my wife Doreen Ayafor Mpafe for her selfless devotion during these past four years when she had to endure my numerous absences and limited attention to family matters to accomplish this Doctoral project.
ACKNOWLEDGMENTS

I owe immense gratitude to my father Bernard Njoumu Mpafe I who initially ingrained in me the idea of accomplishing a Doctoral degree in December 2004. To my mum Mary Pangou Mpafe for her continuous encouragement. Her steadfast belief in my abilities served as a resilient mustard seed for my education growth despite all odds. I am indebted to my sisters Pauline Ngandoh-Mpafe , Bella Mpafe-Tchombe and Vera Wanwio Mpafe for their constant reminders of our shared visions and hope. The keen interest shown by my brothers Nza Nzounewou Mpafe RIP, Nnouno Mpafo, Ndanji Mpafo and Larhlahr Mpafo served as a necessary motivation.

To the administrative staff of University of South Florida Doctor of Business Administration Program who patiently guided me through the numerous administrative requirements over the years; Michele Walpole and Lauren Baumgartner you are the best.

I am thankful to my Doctoral committee (Dr. Sunil Mithas, Dr.Robert Tiller, Dr. Grandon Gill, Dr. Mark Taylor, Dr. Jarrett Loran) for continuously challenged me despite my opposition sometimes to the addition rigor demanded. My final thesis is a testament to your insights. My 2021 Cohorts members invaluable inputs and varied thought processes made of an exciting academic jostling that will be sorely missed.

During this academic journey I was privileged to welcome my son Bernard Njoumu Mpafe II whose presence gave me the hunger and extreme urge to succeed for a better vision for a family. I profusely thank my wife for believing me and allowing me temporarily to abdicate certain responsibilities.
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ABSTRACT

Curbside recycling as a preferred mode of residential and municipal sustainability goals seems to have an overwhelming acceptance and adoption in the US. About 69.8 million out of 97.3 million (72%) single-family households in the United States have access to curbside recycling services (State of Curbside Recycling Report, 2020). Collectively, the programs divert about nine million tons of recyclables from landfill disposal each year (Cottom, 2019).

For a design that started in the 1980s in the US, its rapid universal adoption seems to have precluded a concerted effort in examining the coproduced nature (Households: service receptors and Municipalities: service providers) to ascertain an effective and efficient service optimization mode for both households and municipalities. While it is a universal practice, the has not been a significant increase rate of recycling lately (35.2%), as evidenced; 67.2 million tons of MSW were recycled in 2017, slightly less than the 66.7 million tons recycled in 2015 (EPA 2019). With results such as these recycling program administrators question if we are facing diminishing returns for the entrenched curbside residential recycle programs and what could turn the tide.
CHAPTER ONE:

ARTICLE 1 – RESIDENTIAL CURBSIDE RECYCLE CONTEXT ANALYSIS

HISTORY

Tagline

Cities cover only 2% of the Earth’s surface but produce 70% of the world’s waste. (Zaman et al., 2013). Across the country, landfills are closing, and local leaders protest the opening of new facilities. Americans are still generating 4.5 pounds of trash per person each day, and it has to go somewhere (Zimlich, 2015). When adapted and efficiently designed, residential curbside recycling programs seem to provide an acceptable solution to the principles of reduction, reuse, and recycling.

Keywords and Definitions

Municipal Solid Waste (MSW)

More commonly known as trash or garbage, consists of everyday items we use and then throw away, such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries (Environmental Protection Agency [EPA], 2016). These come from our homes, schools, hospitals, and businesses (EPA, 2016).
Recycling

Process of collecting and processing materials that would otherwise be thrown away as trash and turning them into new products (EPA, 2016).

Material Recovery Facility (MRF)

A facility that receives, sorts, and processes materials in categories, usually determined by the recycling commodity market, for reuse in the manufacturing or repurposing processes. Its core function is to maximize the value of collected recycling and avoid contamination, which will most likely result in the disposal of materials in landfills (Zafar, 2019).

Residential Curbside Recycling.

Curbside recycling programs are designed to capture recyclable commodities primarily from single-family households (The Recycling Partnership, 2020).

Dual Stream

Recycling is pre-sorted by residential households into two categories (and two containers) as determined by the city for curbside collection to MRF.

Single Stream

Commingling recycles in one container for collection and processing in MRF.

Executive Summary

Curbside recycling is a critical aspect in the overall waste management and remediation services industry engaged in collecting, treating, and disposing of waste materials. Establishments in this industry perform local hauling of waste materials, operate materials
recovery facilities, and provide remediation septic pumping and other miscellaneous waste management services. (Bureau of Labor Statistics, 2019). Approximately 65 million households in the United States have curbside recycling services, which collectively divert about nine million tons of recyclables from landfill disposal each year (Cottom, 2019). This analysis aims to provide an overview of the curbside recycling subsector, a contemporary history in North America, and a description of variables affecting curbside recycling design, implementation, and eventual success.

Introduction

Four decades ago, curbside recycling was nonexistent in the U. S. The 1980s was the decade of enlightenment on alternative landfill techniques for trash such as MSW trash, recycle compost, food waste, and yard waste. In 1980, the city of Woodbury, New Jersey, enacted the nation’s first universal mandatory recycling law, requiring all residents to separate recyclables from their trash. Residents reacted with protest by offloading garbage on the lawn of the most vocal proponent of the law, Mayor Don Sanderson. Ironically, the city reached 85% compliance within three months of this mandate (Scottberg, 2018).

Most recycling experts reference the Mobro 4000 incident of 1987 as a turning point in the urgency of disposal alternatives. The Mobro Barge, laden with 3100 tons of trash, left New York City and faced an arduous journey toward the unknown for two months with prospective landfills in North Carolina, Louisiana, Alabama, Mississippi, Florida forbidding dumping. After the Bahamas, Belize, and Mexico also turned down the waste, the captain had to return to New York harbor unceremoniously. Finally, the contents were incinerated, and the resulting ash was landfilled. This incident brought national attention to environmentalists’ continued concern about the need for recycling (Melosi, 1993). Such concerns were further amplified by ordinary
citizens’ consciousness of and opposition to the establishment of landfills near their domiciles, evidenced by the continuous reduction in the number of landfills in the U. S. as shown in Fig 1.

**Figure 1.** Number of Municipal Waste Landfills in the United States, 1990–2017.

*Note. The source for this figure is Statista, 2020.*

By 1985 the U. S. had attained 10% household recycling participation (North East Recycling Council [NERC], 2019). In 1993 Wisconsin issued a statewide ban of all yard waste going to landfills, and later amended the ban to include recycled materials. Such strides led the nation to achieve a 20% recycling rate of all households by 1995 and a 30% rate by 1998 (NERC, 2019).
Phoenix, Arizona was the first U.S. city to establish curbside single-stream recycling as a mandated mode of recycling for household waste. In 1989, Maricopa County, Arizona required Phoenix to provide collection twice per week: one day for collecting recyclables and another for collecting solid waste. The same trucks used for the solid waste collection alternated for recycling, thus ensuring commingling of recycling materials in a single container depository (Guttentag, 1994). Six years later, San Francisco followed suit and adopted single-stream recycling.

The most up-to-date numbers from the Environmental Protection Agency (EPA) indicate that in 2017 approximately 268 million tons of MSW were generated (Figure 2). Of the MSW generated, about 67 million tons of MSW were recycled, and 27 million tons of MSW were composted for a total of 94 million tons, equivalent to a 35.2% recycling (Figure 3) and composting rate (Environmental Protection Agency [EPA], 2019a).

![Figure 2. MSW Generation Rates, 1960–2017.](image)

*Note: The source is EPA 2017 Factsheet (EPA, 2017)*
Types Of Household Recycling Programs

In the United States, there are three recycling options, which are administered by constituted residential authorities (city/town Council, county governments, etc.):

1. Residential Curbside Single-Stream Program: Single receptacle, usually 65 or 95-gallons, is used for all recyclable materials as specified by the municipal authority. Collecting the material on the specified days and depositing in MRFs is the most popular system administer in the U. S. due to its convenience to residents. While of MRFs can be configured either for single or multiple streams, single-stream adaptation has been the most predominant since 2010 (Single-Stream Recycling, 2013).
2. Residential Curbside Dual-Stream Program: This has two separate streams. Beverage and food containers (bottles, glass, cans, aluminum, and steel) are in one bin, while paper products (newspapers, junk mail, office paper stationery) are in another container. They are then collected by a specialized dual-stream truck whose dedicated compartments have two separate receptacles in a single truck (Single-Stream Recycling, 2013).

3. Drop Off Recycling Programs: The community can drop off the recycled material at designated sites. The process requires comparatively more effort by the community’s citizens and is essential when the district has no curbside system. In some cases, drop-off programs are used in combination with curbside programs. With accessibility challenges inherently built-in, it is the most inefficient recycling method when used as the sole method (NERC, 2019).

In the United States, 59% have access to curbside recycling, whether a single-stream or dual-stream, as described above. While 53% have this service-mandated resident subscribed to only 6%. Another 14% of residents in the U. S. have access to recycling subscription services but do not participate. Drop-off recycling programs are available to 21% of residents, and 6% have no service available at all (The Recycling Partnership, 2020).

Design Of a Curbside Recycling Program

Curbside recycling is a coproduction instrument for which the household’s commitment is essential to work with the service providers. Typically, in the production of goods, the behaviors of consumers are independent of the product. Conversely, producers (recyclable producing households) and consumers (MRFs and MSWs) are interdependent in the service industry, and roles might be interchanged based on the household or producer of the service.
Service delivery involving producers and consumers should not have merely passive household inputs (Brudney, 1985). Specific criteria are necessary for the design of coproduced curbside recycling to be successful, including but not limited to:

- **Benchmarking:** Selecting a benchmarking partner (similar city with curbside recycling service) is a valuable tool for success in curbside recycling. A recycling program’s “best fit” benchmarking partner will have widespread support among its residents. The preliminary service quality level should be benchmarked to ascertain whether citizens will acquiesce to new service level changes and identify indicators of efficiency, outcome effectiveness, and quality (measuring current service quality) as well as top performers (municipalities) in desired service quality. Following the accomplishment of benchmarking, actions needed to achieve desired service quality can be prescribed. Once prescribed policies for closing performance deficiencies are identified, they can be adopted, and progress can be monitored (Folz, 2004).

- **Education:** Initial and continuous public education is essential. Communities that engage in round tables, neighborhood groupings, and local school interactions correlate positively to cities with higher recycling participation rates (Folz, 1991). Information-Motivation-Behavior Skill Theory (IMB MODEL) by Fisher & Fisher re-emphasizes the need for informational resources for success. According to this model, relevant information for performing a health behavior is a prerequisite for correct and consistent practice. Education and information on routes, service times, recycling, and what not to recycle (to avoid contamination) should be transmitted to households. The global consequences of not recycling places the burden of guilt or satisfaction subconsciously on the recycler. Education should also negate the
preconceived notion that all or some materials set out for recycling end up in landfills (Seacat & Northrup, 2010).

- Resources: Finances play a vital part in ascertaining curbside recycling viability. A municipality must establish what service they want to offer, such as single or dual-stream and consider if there is an existing MRF to accommodate such material inflow (quantity and type of material picked up from curbside recycling). An MRF can cost about $20 to $30 million to build, so using existing facilities in a county is a more affordable and convenient option for smaller municipalities and cash-strapped cities (Workman, 2018). Municipality waste production quantity from households and the type of curbside recycling (single or dual-stream) must be seamless to avoid downtime, overcapacity, and structural deficiencies (dual-stream MRF can accept single-stream material and vice versa).

- State Laws and Goals: Municipalities historically use the state environmental agency to guide curbside recycling programs’ scope and rigor. Florida and California have self-imposed goals of 75% recycling of all MSW by 2020. Although these states missed these goals, their grants, incentives, and the overall recycling initiative serve as a template for the design and vigor of municipalities’ recycling programs. Municipalities should make achievable goals that mirror their demographics and the level of environmental awareness of their population.
Figure 4. Diagrammatic Presentation of Design and Implementation Elements.

Note. Self-generated diagram explaining the critical factors affecting Residential Curbside recycle design and implementation. This figure is a non-exhaustive presentation of municipalities’ factors when designing and implementing a curbside recycling program. It is not a didactic flowchart that could be chronologically adhered to but does encompass essential elements of program design and implementation.
The Industry

Residential curbside recycling is not a unique, standalone industry. It is usually combined with the overall waste collection quotient, commercial recycling, or municipal utility service industry. This conflicting appropriation of residential curbside recycling into varied spheres makes it uniquely challenging to stratify and analyze its data. An appropriate methodology in accessing the scope of curbside recycling is comparing tons of MSW produced annually in the United States. The annual production of MSW in the U. S. in 2017 was 267.8 million tons (2017). Approximately 67 million tons were recycled and 27 million composted; thus, cumulatively, 94 million were reclaimed from landfills suggesting a recycling rate of 35.2% (EPA, 2019).

Using the direct approach in accounting for household recycling, it is estimated that recycling household materials accounts for 83,000 jobs, $3.9 billion in wages, and $694 million in taxes paid, which equates to 1.57 jobs for every 1,000 tons of material recycled and reused (EPA, 2016). However, using a direct and indirect approach by combining recycling and its related activities accounted for 75,700 jobs, $36.6 billion in wages (more than the 2016 GDP of Vermont and also Wyoming), and $6.7 billion in taxes.

California and Florida have recycling goals of 75% by 2020, while Minnesota has a 2030 goal of 75%. Wisconsin has banned specific recycling from landfills, and Michigan aims to improve their recycling of MSW from the current 15% to 30% by 2025 (a $2 million campaign for recycling education campaign kicked off in 2019). Oregon, with a 52% goal by 2020, demonstrates a positive outlook for residential curbside recycling.

The global market of recycling, which includes residential recycling, faced a significant economic setback in 2018. For the preceding decades, China had been the processor of half the
world’s recycling, including 70% of all U. S. recycled material (Katz, 2019). However, due to its introduction of Operation National Sword legislation, China began seeking alternatives for processing recycling material. Operation National Sword banned twenty-four types of waste material and other contaminated recycle materials imports while setting a stricter standard for contamination levels. This ban caused a dramatic decline in recycling material value and concurrently increased the cost of residential curbside recycling, making it less cost-efficient to municipalities. The blended price of recycling material output from MRF dropped from $90 in 2017 to $24 in 2019.

Additionally, the processing cost for such recycling, as estimated by the North East Recycling Coalition (NERC), was $83 while The Recycling Partnership surveys estimated a cost of $82. Using an $80 per ton processing baseline leaves a $56 a ton (cost to process recycling material less the price in open market for recycled MRF output per ton) unrecovered expense. Instead of receiving financial remuneration for recycling commodities, many municipalities have had to pay an increased processing fee. The consequences of Operation National Sword have been the elimination of fifty-four municipal curbside recycling programs. Additionally, other programs reduced the recycling materials or increased residential curbside recycling costs (The Recycling Partnership, 2020).

In some cases, Operation National Sword spurred investments, innovation, and re-education on recycling. As Recology C.E.O. Michael Sangiacomo explained, “China’s National Sword policy specifically targeted the purity of global wastepaper.” He explained that “[w]hile many U. S. recyclers continue to struggle to meet these new standards, our investments in state-of-the-art sorting technology have allowed us to meet necessary contamination thresholds and sell our product to Taiwan, India, Korea, Mexico, Indonesia, and Malaysia” (Sangiacomo, 2019).
As a result, investment and new markets (other than China), coupled with innovative reuse of products in the USA, will significantly benefit the industry.

Operation National Sword led some municipalities to adopt the following:

- Greater Birmingham, San Francisco instituted programs to decreased contamination. They educated their populations on what to recycle with the onus on citizens to start curbside recycling in an informed, deliberate fashion rather than just absentmindedly tossing in the bin.

- Washington, D.C. implemented a pilot program with a recycling partnership organization that asked for feedback on recycling from residents and sent mailers clarifying depositing plastic in recycling to counteract its most pervasive issue. Additionally, the tagging of residents with plastic in the recycle bin proved useful.

- Domestic markets: Montgomery County did not stop recycling and now sells most of its bales domestically and pays to recycle mixed-color, broken glass because it has little value.

Operation National Sword, although immediately detrimental, seems to be a catalyst for change, reinvigorating the domestic recycling capacity and leading to investment in equipment to handle further processing and varied output configurations (Javorsky, 2019).

Currently, the U. S. has no coherent national curbside recycling leadership. The EPA allows for each state’s autonomy in decision-making regarding recycling. However, in January 2018, just ten months after Operation National Sword, the EPA held its first-ever recycling summit. In 2019 the second summit published the national framework to advance U. S. recycling (EPA, 2019). At the first gathering of stakeholders, Barry Breen (EPA Acting Assistant Administrator of the Office of Land and Emergency Management) stated, “we hope that together
among ourselves and with others who are interested in joining over the next several months, we can develop a national action plan.” Discussion on perspectives and plans resulting from recent market disruptions (caused by Operation National Sword) and the need to improve domestic recycling systems, including collection, infrastructure, and end markets for recovered materials (EPA, 2018).

Table 1. U. S. Recycling by States: Laws/Goals and Recycling Rates.

<table>
<thead>
<tr>
<th>State</th>
<th>Goal</th>
<th>Mandate</th>
<th>Outlook</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>25% recycling 25% attained 2018</td>
<td>Solid Waste &amp; Recycling Material Management Act 335-13-13-.02. Established a statewide solid waste reduction goal of 25%.</td>
<td>According to the Alabama Department of Environmental Management 2018, diverting more than 25 percent of all the trash generated in the State from landfills for the first time since the State started closely tracking where its garbage goes.</td>
<td>(Pillion, 2019) (Alabama Department of Environmental Management Land Division—Solid Waste Program, 2020)</td>
</tr>
<tr>
<td>Alaska</td>
<td>No state-mandated goal 25% using our recycle services in Anchorage in 2017. Statewide data not available</td>
<td>AS 46.06.031. Solid and Hazardous Waste Reduction and Recycling Program; established within the department a solid and hazardous waste reduction and recycling program</td>
<td>N/A</td>
<td>(Anderson, 2017)</td>
</tr>
<tr>
<td>State</td>
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<td>Mandate</td>
<td>Outlook</td>
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<tr>
<td>Arizona</td>
<td>No state-mandated goal</td>
<td>Individual cities are encouraged through the Arizona Department of Environmental Quality to recycle</td>
<td>None</td>
<td>In 2050, Phoenix will create ZERO WASTE through participation in the “Circular Economy.” In the short term, we will proceed on the target to divert 40% of waste by 2020.</td>
</tr>
<tr>
<td>Arkansas</td>
<td>No state-mandated goal</td>
<td>45.5% recycling rate 2017 vs. 46.6% Recycling rate 2016</td>
<td>No state goal for recycling, but in 1991, the Arkansas Legislature passed Act 749, making it the policy of the state “to encourage and promote recycling to conserve natural resources, save energy, and preserve landfill space.”</td>
<td>N/A</td>
</tr>
<tr>
<td>California</td>
<td>75% recycling of MSW.</td>
<td>Currently, California Recycle is at the mid 40%, a reduction from 50% in 2014.</td>
<td>Assembly Bill 341, which was signed into law in 2011 and called for a statewide goal of 75% source reduction, recycling, and composting by 2020</td>
<td>Not predicted to meet 2020 goals</td>
</tr>
<tr>
<td>Colorado</td>
<td>28% diversion by 2021.</td>
<td>Colorado’s statewide recycling rate dropped in 2019 to 15.9%, down from 17.2% in</td>
<td>Recycling Resources Economic Opportunity Program instituted by the Department of Public Health and Environment</td>
<td>Lags behind the national average and must substantially pick up the pace if they are to meet their own modest recycling goals</td>
</tr>
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<tr>
<td>Connecticut</td>
<td>Divert, reduce, reuse, and recycle 58% of municipal solid waste by 2024.</td>
<td>In 2015 35% of waste was recycled and composted in Connecticut.</td>
<td>Section 22a-208v and Section 22a-256a of the Connecticut General Statutes and Section 22a-241b of the Regulations of the Connecticut State Agencies include a list of items that must be recycled.</td>
<td>(<a href="https://nerc.org/state-information/ct/ct-information/ct/ct-program-overview">https://nerc.org/state-information/ct/ct-information/ct/ct-program-overview</a>, NERC, 2020)</td>
</tr>
<tr>
<td>Delaware</td>
<td>60% residential and commercial diversion by 2020.</td>
<td>37.6% recycling rate attained in 2018.</td>
<td>Delaware’s landmark Universal Recycling Law made it the first and only State requiring access to single-stream recycling for all residents and businesses.</td>
<td>Through its 2016 grant cycle, the Fund has awarded $9.2 million in grants primarily for residential single-stream recycling and multi-family, commercial, schools, and public outreach. Since 2006 recycling rate has been improving.</td>
</tr>
<tr>
<td>Florida</td>
<td>75% recycling by 2020.</td>
<td>The statewide overall recycling rate, which includes renewable energy recycling credits, decreased from 52% (2017) to 49% (2018).</td>
<td>The Legislature set a 75% statewide recycling goal for municipal solid waste by 2020. The Legislature also put that same goal for all counties over 100,000 population. The Legislature has directed all counties to report their recycling progress to DEP annually.</td>
<td>Not predicted to meet 2020 Goals</td>
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Table 1 (continued)

<table>
<thead>
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<td>Not predicted to meet 2020 Goals</td>
<td>(Moore, 2020)</td>
<td></td>
</tr>
<tr>
<td>Georgia</td>
<td>No state-mandated goal</td>
<td>Georgia Recycling Economic Development Partners backed bill got approval in 2020 for hazardous waste and recycling revenue to be used only for intended purposes, Georgia Amendment 1: Georgia’s Amendment 1 would dedicate all taxes or fees to the specific program or purpose to which the taxes or fees were imposed. Currently, dedicated fees can be used for other purposes. For example, due to diversions, the $1 fee on new tires (the tire landfill fee), which is supposed to be deposited into the Hazardous Waste and Solid Trust Fund to pay for the disposal of used tires, is diverted to the State’s General Fund. If Amendment 1 is approved, all dedicated revenue would be used as intended beginning in 2021.</td>
<td>Some area recycling professionals believe the newly bolstered funding could help prioritize more than $1 million per year for a range of recycling initiatives in a state limited by budget cuts years ago.</td>
<td>(<a href="https://www.georgiapolicy.org/2020/10/voters-guide-to-the-2020-georgia-ballot-initiatives/">https://www.georgiapolicy.org/2020/10/voters-guide-to-the-2020-georgia-ballot-initiatives/</a>, Foundation News, 2020)</td>
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<td>Hawaii</td>
<td>In 2020 the State Legislature proposed amending Chapter 342G-003 to raise the State’s waste diversion goal from 50% to 70% by 2030 to codify the Aloha+ Challenge.</td>
<td>Current recycling at 19.2% for 2019</td>
<td>2011 Hawaii Code Division 1. Government Title 19. Health 342G. Integrated Solid Waste Management; The Goal of the State [is] to reduce the solid waste stream.</td>
<td>Hawaii is not forecasted to meet its goals</td>
<td>(Office of solid waste management annual report to the thirtieth legislature state of Hawaii, March 2020)</td>
</tr>
<tr>
<td>Idaho</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Illinois</td>
<td>Each plan established by county and state must have a minimum of 25% diversion or recycling goal</td>
<td>The State has reached a recycling rate of 37 percent</td>
<td>Under the Solid Waste Planning and Recycling Act (SWP&amp;RAct), 1992, all Illinois counties and the City of Chicago were required to develop comprehensive solid waste management plans by March 1, 1995. Each plan must include provisions for implementing a recycling program designed to recycle 25 percent of the municipal waste generated in their jurisdiction. In addition, this law has been amended to encourage counties to undertake solid waste management planning on a multi-county, regional basis through inter-governmental cooperation agreements.</td>
<td>Goal assessed as tepid as compared to most environmentally conscious states</td>
<td>(Illinois Launches two Statewide Sustainability Initiatives, Recycling Today 2011)</td>
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<tr>
<td>Indiana</td>
<td>50% recycling and diversion goal</td>
<td>Current recycling at 20% for 2018</td>
<td>2014 House Bill 1183, which seeks to put in place policies that will result in recycling levels in the State to increase to 50 percent</td>
<td>Haulers in Indiana have been raising monthly rates for curbside recycling, causing reduced enthusiasm</td>
<td>(IDEM 2018 Recycling Activity Summary, Nov 2019)</td>
</tr>
<tr>
<td>Iowa</td>
<td>50% recycling and diversion goal</td>
<td>Current recycling at 30%</td>
<td>Iowa Code Section 455B.302 requires every city and county to establish and operate a comprehensive solid waste reduction program consistent with the waste management hierarchy in 455B.301A.</td>
<td>Iowa is not forecasted to meet its goals</td>
<td>(<a href="http://www.io">http://www.io</a> wadnr.gov/Insi deDNR/Regulat oryLand/Solid Waste/SolidW astePolicyRule s.aspx Jan 2021)</td>
</tr>
<tr>
<td>Kansas</td>
<td>N/A</td>
<td>Kansas Department of Health and Environment says the State’s recycling rate had risen from about 18 percent in 2005 to 34 percent in</td>
<td>The State’s Solid Waste Management Act requires every county or consolidated group of counties to prepare solid waste-management plans containing provisions for reducing waste volumes through source reduction, composting, land disposal, and recycling. KDHE must approve these plans.</td>
<td>The recycling rate dropped to 32% in 2016</td>
<td>(2016 State Solid Waste Management Plan, Kansas Department of Health and Environment, 2016)</td>
</tr>
<tr>
<td>Kentucky</td>
<td>N/A</td>
<td>Recycling rate of 38.2 percent in 2017</td>
<td>N/A</td>
<td>Division of Waste Management increased budget and recycling programs have led to an increase in recycling even without legislation</td>
<td>(The Fiscal Year 2018 Annual Report, Department of Waste Management, 2018)</td>
</tr>
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<tr>
<td>Louisiana</td>
<td>N/A</td>
<td>Recycling rate of 12.87 percent in 2018</td>
<td>R.S. 30:2421 - White goods; disposal prohibited; collection for recycling</td>
<td>N/A</td>
<td>(Annual Recycling Report 2018, Louisiana)</td>
</tr>
<tr>
<td>Maine</td>
<td>50% of our municipal solid waste generated</td>
<td>The most recent numbers (for 2016) show that Maine’s municipal solid waste recycling rate is 36.79%.</td>
<td>2132. Municipal recycling: Municipalities are not required to meet the state recycling goal in section 2132, but they must demonstrate reasonable progress toward that goal.</td>
<td>N/A</td>
<td>(Maine Department of Environmental Protection)</td>
</tr>
<tr>
<td>Maryland</td>
<td>Voluntary waste diversion goal of 55% by 2020</td>
<td>Maryland achieved a statewide waste diversion rate of 47.9% in a calendar year (C.Y.) 2018.</td>
<td>In 1988, the Maryland Recycling Act (MRA) authorized MDE to reduce solid waste disposal in Maryland through management, education, and regulation.</td>
<td>Continuous improvement since 2015</td>
<td>(Maryland Department of the Environment)</td>
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<tr>
<td>Massachusetts</td>
<td>Draft 2030 Master Plan reduces waste disposal by 30%. MassDEP’s 2010–2020 Solid Waste Master Plan sets 2008 as the baseline, with short- and long-term goals to reduce annual solid waste disposal by 30% by 2030 and 80% by 2050.</td>
<td>Massachusetts generates 13.9 million tons of waste generated annually, and 52% (7.2 million tons) is recycled or diverted.</td>
<td>Section 8H. A city, town, or district may establish, by approval of the local legislative body, a recycling program to recycle any type of solid waste, including but not limited to paper, glass, metal, rubber, plastics, used tires, and compostable waste. The program may be established for groups of cities, towns, or districts upon agreement of all municipalities or communities in a joint program.</td>
<td>N/A</td>
<td>(Massachusetts Department of Environment)</td>
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<tr>
<td>Minnesota</td>
<td>75% by 2020</td>
<td>Minnesota Posted a combined recycling rate of 46% in 2018, the highest since the Select Committee on Recycling and the Environment (SCORE) in 1991.</td>
<td>115A.551 RECYCLING Metropolitan Solid Waste Management Policy Plan 2016 – 2036: metro counties set a goal to recycle and compost 75 percent of solid waste by 2030. For a county outside of the metropolitan area, 35 percent by weight of a total solid waste generation</td>
<td>Every year since the SCORE data was kept has seen an improvement 2016-2017-2018 with 33.55%-44.75%-46% respectively. Making plausible for 2030 goal could be attained</td>
<td>(The Score Report, 2019) (Office of the Revisor of Statutes Minnesota, 2018) (Solid Waste Policy Report, 2019)</td>
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<td>Mississippi</td>
<td>N/A</td>
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<td>Missouri</td>
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<tr>
<td>Montana</td>
<td>The Montana Integrated Waste Management Act (75-10-803 MCA) Ultimate goal of 22% for 2016</td>
<td>17.11% recycling rate in 2016</td>
<td>The Montana Integrated Waste Management Act (75-10-803 MCA) directs Montana to reduce solid waste disposal volume in landfills.</td>
<td>Montana did not meet 2016 goals and is regressive from 2013 and 2015 higher diverted recyclables</td>
<td>(State of Montana 2016 Recycling and Waste Diversion Summary)</td>
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<tr>
<td>Nebraska</td>
<td>The goal of diverting 50% of waste from</td>
<td>Lincoln estimates its recycling rate at 22 percent</td>
<td>LB1257: the Integrated Solid Waste Management Act (1992)</td>
<td>(The official site of the Nebraska Unicameral Legislature)</td>
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<td>landfills by 2002</td>
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<td>Nevada</td>
<td>1991 the Nevada Legislature adopted a</td>
<td>In 2011, 2012, and 2013 the rate met or exceeded the 25% goal.</td>
<td>Per legislation NAC 444A.110-140 Nevada counties with an approved recycling plan must report the number of materials diverted from landfills through recycling to reach a recycling rate of 25% two years after implementation.</td>
<td>Nevada has exceeded its goal in 2011, 2012 and 2013, but lately, in 2017, 2018, 2019, the recycling rate was 21%, 22%, and 21.7% below the goal</td>
<td>(Nevada Division of Environmental Protection)</td>
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<td>recycling goal of 25%</td>
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<td>New Hampshire</td>
<td>40% goal for 2020</td>
<td>N/A</td>
<td>Solid Waste Management Section 149-M:2: The general court declares that the Goal of the State, by the year 2000, is to achieve a 40 percent minimum weight diversion of solid Waste landfilled</td>
<td>N/A</td>
<td>New Hampshire Department of Environmental Services</td>
</tr>
<tr>
<td>New Jersey</td>
<td>In 1992 this law was revised, and new</td>
<td>In 2017, the New Jersey Department of Environmental Protection documented the recycling of over 14 million tons of total solid Waste (municipal solid Waste plus industrial) for a real recycling rate of 60%.</td>
<td>New Jersey Statewide Mandatory Source Separation and Recycling Act–NJSA 13:1E-99.11 et seq, Amendments till 2020</td>
<td>Goal achieved and continuous improvement through legal and grant awards.</td>
<td>(State of New Jersey Department of Environmental Protection)</td>
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<td>goals were established—a recycling rate</td>
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<td>of 50% of municipal solid waste and 60%</td>
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<td>of total solid waste (which includes</td>
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<td>municipal and industrial waste)</td>
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<tr>
<td>New Mexico</td>
<td>50% recycling goal by 2000</td>
<td>2016 recycling rate 17%</td>
<td>The New Mexico Solid Waste Act set a goal of diverting 25% of the Waste generated in New Mexico from landfills by 1995 and 50% by 2000.</td>
<td>At 19 percent, the statewide rate falls almost 16 points below the national average of 34.7 percent, based on the most recent available data. In other words, 81 percent of the Waste in New Mexico goes to landfills, incinerators</td>
<td>(Environment New Mexico Research &amp; Policy Center)</td>
</tr>
<tr>
<td>New York</td>
<td>The long-term goal of New York State is to reduce waste disposal to 0.6 pounds per person per day by 2030 by maximizing waste reduction, recycling, and resource recovery and significantly reducing the amount of waste destined for management in a municipal waste combustor or disposal at landfills</td>
<td>N/A</td>
<td>In the Solid Waste Management Act of 1988, the New York State Legislature established our State Solid Waste Management Policy and Local Law 40 of 2010 set recycling goals for Sanitation-managed solid Waste</td>
<td>N/A</td>
<td>(New York Solid Waste Management (SWM) Planning)</td>
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<td>North Carolina</td>
<td>To reduce through source reduction, reuse, recycling, and composting on a statewide per capita basis the amount by weight of solid waste disposed at municipal solid waste disposal facilities from July 1, 1991, through June 30, 1992, by twenty-five percent (25%) by 1993, and forty percent (40%) by 2001.</td>
<td>North Carolina landfill over 9.7 million tons of waste* and recovered 1.7 million tons for a recovery rate of 14.9%. Since 2017, it appears that North Carolina’s recycling system has declined.</td>
<td>N.C. General Statute 130A-309.14. Establish a program to collect and recycle aluminum, newspaper, office paper, glass, and plastic bottles. N.C. General Statute 130A-309.10 Materials banned from disposal in the landfill - see section (f)</td>
<td>At 14.9% in 2017, even the 2001 goal were not met</td>
<td>(North Carolina recycling and solid waste management plan)</td>
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<tr>
<td>North Dakota</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>No current data, however, with Solid Waste disposal being one of the lowest in the country coupled with a 35% contamination rate of single-stream recycling</td>
</tr>
<tr>
<td>Ohio</td>
<td>50% Reduce and Recycle Goal</td>
<td>2019 Residential and Commercial Recycling 28.37%</td>
<td>The 2009 State Solid Waste Management Plan.</td>
<td>2019 is way below the 2009 goal of 50%</td>
<td>(Ohio Statutes-Titles 27A. Environmental and Natural Resources)</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>Oklahoma Solid Waste Management Act (“Act”) 27A O.S. § 2-10-205(A), which set a goal of recycling at least 10%</td>
<td>No recent data is available</td>
<td>Act 27A does not mandate recycling however encourages participation towards goal</td>
<td>No current data, however, with Solid Waste disposal being one of the lowest in the country coupled with a 35% contamination rate of single-stream recycling</td>
<td>(Oklahoma Statutes-Titles 27A. Environmental and Natural Resources)</td>
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<tr>
<td>Oregon</td>
<td>52% by 2020</td>
<td>40.8% recovery rate, down from 41.6% in 2017, according to an April report from the Oregon Department of Environmental Quality (DEQ).</td>
<td>Senate Bill 263 (2015) updated the statewide recycling goals. Increase the waste recovery goal from 50 percent to 52 percent by 2020, and to 55 percent by 2025</td>
<td>2017 was the sixth year in a row the rate declined. It hit a peak of 49.7% in 2012. Meaning 52% is plausible</td>
<td>(Oregon Senate Bill 263, 2015). (Pabon, 2020).</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>In 1997, the Commonwealth raised that goal to 35% by 2002</td>
<td>In 2017, over 6.36 million tons of recyclable materials were collected and processed in Pennsylvania, less than 2016 numbers of 7.84 million</td>
<td>Mandated by Act 175 of 2002, which modifies Act 101 of 1988, “The Municipal Waste Planning, Recycling, and Waste Reduction Act”</td>
<td>At present, 440 of Pennsylvania’s 2,700 municipalities are mandated to recycle and provide curbside collection programs. That is of 94 percent of the population which couple existed laws make the current goal achievable</td>
<td>Pennsylvania Department of Environmental Protection</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>Recycle a minimum of thirty-five percent (35%)* of its solid waste</td>
<td>Rhode Island’s overall diversion rate is estimated to be 34 percent (CY2017)</td>
<td>State Law §23-18.9-1 mandates a two-part goal for municipalities: Every city or town that enters into a contract with the RIRRC for solid Waste is required: to recycle a minimum of thirty-five percent (35%)* of its solid waste and to divert a minimum of fifty percent (50%) of its solid waste.</td>
<td>Residential curbside recycling by 2016 was already over the goal of 34% at 37%</td>
<td>(Recycling Economic Information and Diversion Rate Study for Rhode Island Final Report, June 2018)</td>
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<tr>
<td>South Carolina</td>
<td>Recycle at least 40% of its MSW</td>
<td>28.1% 2018 South Carolina recycling rate was 28.1%</td>
<td>No Stated mandate/ Law enforcing recycling</td>
<td>The most recent recycling rate at 28%. Goal of 40% still looks pretty elusive</td>
<td>(South Carolina Department of Commerce: Recycling Market Development Advisory Council 2018 Annual Report) (South Carolina 2019 Solid Waste Management Report)</td>
</tr>
<tr>
<td>South Dakota</td>
<td>N/A</td>
<td>The State of South Dakota in 2011 achieved an estimated MSW recycling rate of 18.5%</td>
<td>N/A</td>
<td>The DENR Waste Management Program estimates that approximately 56% of the population in South Dakota has reasonable access to an MSW recycling program</td>
<td>(State of South Dakota Recycling/Diversion Report, 2011)</td>
</tr>
<tr>
<td>Tennessee</td>
<td>Tennessee’s current waste reduction and diversion goal of 25% waste reduction and diversion</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>(Tennessee Department Environment and Conservation: 2015 - 2025 Solid Waste and Materials Management Plan)</td>
</tr>
<tr>
<td>Texas</td>
<td>N/A</td>
<td>Based on the tons of municipal solid waste recycling reported for this study, the 2015 recycling rate for municipal solid waste in Texas was 22.7 percent.</td>
<td>N/A</td>
<td>N/A</td>
<td>(Texas Commission on Environment Quality: Study on Economic Impact Recycling)</td>
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<td>Utah</td>
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<tr>
<td>Vermont</td>
<td>The agency of Natural resources of Vermont goal of recycling is 50%</td>
<td>Out of all the waste Vermont generates annually, only about 35% gets sent somewhere other than a landfill to be recycled, composted, or reused.</td>
<td>In 2012, the Vermont Legislature unanimously passed the Universal Recycling Law (Act 148), which bans three significant categories of materials from Vermonters’ trash bins</td>
<td>For the past decade recycle rate has stagnated between 30% and 36%</td>
<td>(State of Vermont: Recycling &amp; Climate Change)</td>
</tr>
<tr>
<td>Virginia</td>
<td>25% recycling rate per Virginia Code</td>
<td>Under Virginia Code § 10.1-1411.D, each SWPU is required to achieve and maintain a minimum 25 percent annual recycling rate unless its population density is less than 100 persons per square mile, or its civilian unemployment rate is 50 percent or more above the state unemployment average</td>
<td>Based on the information provided by the localities, the CY2019 recycling rate decreased due to recycling challenges faced by the industry and the difficulty obtaining recycling information from private businesses due to the COVID 19 pandemic.</td>
<td>Based on the information provided by the localities, the CY2019 recycling rate decreased due to recycling challenges faced by the industry and the difficulty obtaining recycling information from private businesses due to the COVID 19 pandemic.</td>
<td>(Virginia Annual Recycling Summary Report)</td>
</tr>
<tr>
<td>Washington</td>
<td>50% recycling goal by 2000</td>
<td>2015 47%; 2016 47.6%; 2017 48.5%</td>
<td>CHAPTER 431 [Substitute House Bill No. 1671]</td>
<td>From 2009 to 2013, state goal of 50% was accomplished</td>
<td>(State of Washington: Department of Ecology, Waste Generation and Recovery Data, 2017)</td>
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<td>West Virginia</td>
<td>The West Virginia Recycling Act established disposal goals to reduce the per capita disposal of solid waste by 50% by January 1, 2010, of the amount of solid waste disposed of in 1991.</td>
<td>A study completed in the spring of 2002 by the W.V. Recycling Measure-ment Committee, a group of both public and private sector individuals, indicated that 16% of the waste stream was being recycled at the time. Unfortunately, this figure is deceptive due to the lack of reporting requirements.</td>
<td>The original West Virginia Recycling Act, created in 1989, is now the A. James Manchin Rehabilitation Environmental Action Plan §22-15A emphasizes the importance of integrated waste management. This involves a combination of techniques and programs to manage municipal solid waste. Instead of immediately developing large, high-technology programs or setting unrealistic expectations about what portion of the waste stream can be recycled, decision-makers implement a series of smaller, complementary programs. The system supports the waste management hierarchy: source reduction, reuse, recycling, and landfilling.</td>
<td>The state has no reliable, current recycling information. (West Virginia Solid Waste Management Plan, 2019, prepared by the West Virginia Solid Waste Management Board)</td>
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<tr>
<td>Wisconsin</td>
<td>Wisconsin has not established any statewide goals for waste reduction, recycling, or compost</td>
<td>Wisconsin’s 1990 Solid Waste Reduction, Recovery, and Recycling Law requires everyone in the State to recycle, whether at home, at work, or away-from-home settings like fairs, festivals, sports events, conferences, and meetings. Every Wisconsin community has a recycling ordinance with language similar to that of the state law. The State of Wisconsin, and two of its communities in particular—the City of Madison and Waukesha County—are using regulations and ordinances in conjunction with public outreach and education as tools to enhance their public place recycling programs</td>
<td>No relevant current information is available</td>
<td>(Wisconsin Department of Natural Resources: Wisconsin’s Waste Reduction and Recycling Law)</td>
<td>(Wisconsin Department of Natural Resources: Wisconsin’s Waste Reduction and Recycling Law)</td>
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An analysis of recycling by state shows states with recycling goals, mandates, or a law of 50% or higher recycling rate, whether legally binding or not, have an average rate of 38.1%, as seen above in California, Connecticut, Delaware, Florida, Hawaii, Indiana, Iowa, Maine, Massachusetts, Minnesota, Nebraska, New Jersey, Ohio, Oregon, Vermont, and Washington. However, in states without goals or regulation or whose mandates fall below 50% (Alabama,
Arkansas, Colorado, Illinois, Michigan, Montana, Nevada, North Carolina, Rhode Island, South Carolina, Virginia), recycling rates equate to 27%. Arkansas, Illinois, Rhode Island, and Virginia are the only outliers with either no goals or goals/mandates below 50%. Despite their low or nonexistent goals, these states have individual recycling rates comparable with states that have higher goals. Elimination of these outliers results in a 20% recycling rate for states with low goal low or no goals, way below the 2017 national recycling rate of 35.2% (EPA, 2019).

While a statistical inferential analysis is needed to prove direct correlation from the data above, we could surmise the following: goals, mandates, and laws relating to recycling, whether binding or not, affect the recycling participation of the household as they may provide social pressure and an aspirational vision of community. These results offer a certain level of credence to the IMB Model since higher goals and mandates seem to communicate the necessary information to state residents about a healthy and positive recycling behavior that might spur action to attain such a goal.

**Discussion/Analysis**

It would be naïve to assume a definitive list of stakeholders since this service and its reverberations seem infinite. Environmentalists might argue that even the unborn, due to global warming and the finite nature of the world’s resources, are stakeholders, making recycling and reuse a primal concern of humanity.

SWOT analysis in conjunction with stakeholder overview will attempt to give a synopsis of the industrial outlook. A partial list of stakeholders might therefore include:

- Residential household
- Municipal (city or county) government
• Private contractor (contractors who solicit contracts to collect residential recycle on behalf of cities and counties)
• Landfills
• Material Recovery Facilities (MRFs)
• The Environmental Protection Agency (EPA) and state environmental agencies
• CDL (Commercial Driver license) drivers and helpers

A better way of understanding this service delivery and its stakeholders is to divide them into service providers, service receptors, service regulators, and service oversight, as seen in Figure 5.

![Figure 5. Stakeholder Outlay.](image-url)
**Service Provider**

Service providers include city and county government entities or private contractors. In 1985, 35% of cities had contracted an outside contractor (such as Waste Management, Wastepro, or Progressive Waste) to perform the curbside collection of recycling and other MSW services. By 1995 that number had increased to 50%. By 2010, municipalities controlled just 22% of MSW collection revenue (Gerlat, 2011). As a coproduced service delivery, privatization adds agency (city as principal and recycling contractor as agent) dynamics into the spectrum.

However, most cities see cost savings as a compensatory element for outsourcing. Thus, privatization through a competitive bidding process began and has reduced costs by 20% to 60% while improving service quality (EPA, 1999). Political affiliations and changes in municipal government officials can lead to changes in environmental policies and administration for households. When administrative changes occur, policy changes often follow, creating an inconsistency in the messaging process.

![Service Provider SWOT Analysis](image)

**Figure 6.** Service Provider SWOT Analysis.
Service Receptor

As municipalities, states, and the EPA continue the trend of environmental consciousness and sustainability, as shown by the launching of the annual EPA recycling summit in 2018, curbside recycling participation and education is likely to become center stage for stakeholders (EPA, 2018). In a Pew research center survey in 2017, 74% of U. S. adults said the nation should do whatever it takes to protect our environment, compared to 23% who said its actions had gone too far. Admittedly, views of environmental protection have become increasingly partisan over time. According to Andersen’s Pew exposé in 2016, 58% of Republicans said environmental laws cost jobs and hurt the economy, up from 34% in 2007, while 72% of Democrats and Democratic-leaning voters cite ecological protection as the top priority for Congress and the President. Such disparities in opinion highlight the importance of sustainability information and its latent conduit, such as curbside recycling. Furthermore, 32% of U. S. adults voice their distress when they throw away a recyclable item (Anderson, 2017).

The U. S. 2018 budget proposal had a 31% cut in funding for the EPA, consistent with cuts in 2017 ($8.06 billion), 2018 ($8.1 billion), and 2019 ($7.95 billion). While 2020 saw a 12.4% increase, there was only a modest 1.4% increase in science and technology programs and a 0.19% increase for Environmental Programs & Management (Federal Budget Tracker, 2020).
Conclusion

At less than fifty years old, curbside recycling is a recently developed practice. Its rapid growth and adaptation among communities belie the intricacies involved in adapting and implementing a successful program. Moreover, curbside recycling’s recovery of only 32% of available recyclables in single-family homes undercuts its availability and leaves a 68% zone of opportunity in the recovery of MSW to support the economy, address climate change, and keep recyclable commodities out of landfills (The Recycling Partnership, 2020).

The Operation National Sword program disrupted the market for curbside recycling output. Its effect will continue in the short term, especially for municipalities facing budget constraints and considering dropping such programs. With the EPA increasing its focus on recycling and alternatives to Chinese recycling output, adaptation to current circumstances is ongoing. The U. S. looks domestically to resolve the consequences of Operation National Sword.
For instance, more papers mills have announced the new capacity to process recycled paper, making the U. S. recycling market less dependent on the whim and caprices of foreign markets (Javorsky, 2019). Operational National Sword has also spurred Europe and the U. S. to invest in their long-underfunded domestic recycling schemes (Moreton, 2020).

*Intentional participation* is critical for success in coproduced delivery mechanisms where the control of action is cumbersome. Success will continue to be elusive unless there is a defined, determined, and deliberate way of enhancing recycling action through code enforcement, tagging, and continuous education. Educating and informing households is indispensable to avoid contamination of recycling loads, which will end in the landfill rather than the MRF. The householder’s recycler should know what is recyclable and what is not and intentionally participate in avoiding contamination. The average contamination rate among communities and businesses sits at around 25%; roughly one in four items placed in a recycling container is not recyclable through curbside programs, creating enormous problems for the recycling economy (Waste Management, 2018).

The industry is increasingly transferring the role of MSW departments from service providers to supervisory departments of outside contractors who accomplish curbside collection. The cost savings has minimized the concern of control of service by municipalities. As Toledo’s Lucas County sanitary engineer Jim Shaw posited, “[i]t is not economically feasible to continue to provide waste service,” so the city (county?) privatized its waste and recycling operation to Republic Services Inc. (Gerlat, 2011). Privatization introduces loss of control and agency, and the private entities’ ability to seamlessly transcribe municipalities’ recycling goals to residents should receive additional scrutiny. Public institutions must continuously ask if private entities can fulfill their vision and environmental objectives.
The EPA’s annual conferences and renewed interest in recycling, despite its stagnant budget, have revitalized impetus for curbside recycling. As a result, industry awareness will increase and perhaps provide national direction, which has been almost nonexistent compared to other developed countries’ focus on environmental policy. While there is no coherent national policy of curbside recycling, individual states have stepped in. As seen in the various goals, laws, and mandates, an authoritative body that provides a general direction, whether binding or not, can achieve results.
References


Scientific American. 2013. Single-Stream recycling. It’s sweeping the country, but does it lead to more recycled material and less trash in the landfill? https://www.scientificamerican.com/article/single-stream-recycling/


CHAPTER TWO:
ARTICLE 2 – INCENTIVES AND REMINDERS PROMPT IN MUNICIPALITIES
CURBSIDE RECYCLE PROGRAMS AS A CONDUIT FOR SUSTAINABILITY
BEHAVIOR MANAGEMENT OF ITS RESIDENTS

Introduction

Between their inception in the 1980s and 2020, the United States has seen a rapid expansion of available curbside recycling programs. Currently, 59% of U.S. households have access to such programs, which amounts to about 69.8 million homes (Recycling Partnership, 2020). As a result, the percentage of the amount of recycled material that municipal authorities collect with solid waste (i.e., landfill trash) has increased progressively, plateauing in 2017, where it was 35% recycling out of 94 million tons of recycled and composted waste. Daily waste increased from 2.7 pounds to 4.9 per individual between 1960 and 2018, while the recycling rate has stagnated between 1.1 pounds to 1.2 pounds since 2014. The change in how much waste individuals generate (MSW) typically mirrors how much money households spend on goods and services. The Personal Consumer Expenditure (PCE) unit measures household spending on goods and services such as food, clothing, vehicles, and recreation services; these items make up 70% of the Gross Domestic Product (GDP). As the PCE increases, so too does the MSW (Environmental Protection Agency, 2020).

Currently, curbside recycling faces the most critical period of its four-decade history in the U.S., due to Chinese authorities enforcing a scrap ban and the National Sword customs-contamination rule. For decades, China had been handling half of the world’s recycling, processing 70% of all U.S. recycled material. In 2017, China passed the National Sword law, banning 24 types of waste material and setting stricter standards for acceptable contamination
levels of recycled matter. This law effectively banned importing plastic and other contaminating materials into China.

One of the consequences of China’s bans on the U. S. is that the leadership of 54 American municipalities eliminated curbside recycling programs. Other U. S. programs also reduced the kinds of materials that are recyclable or increased the cost of residential curbside recycling for residents. Leaders instituted new laws, banned the import of specific types of waste, and placed stricter contamination limits on recycling materials; these efforts also resulted in lessening the value of recycled matter.

To sustain curbside recycling, individuals must be intentional in their decision to participate continuously. By so doing, they may prevent China or other recycling nations’ authorities from rejecting recycling materials and causing landfiling. We contend that an efficient and effective model of curbside recycling requires three essential elements: curbside access; individual intention to participate; and participant-capture behavior (Recycling Partnership, 2020).

Access to curbside recycling is at almost 60% across the country, but the actual recycling rate remains at 35%, suggesting that authorities will have to find ways of generating spurs to action. Previous efforts of stakeholders to generate internal and psychological motivators have, however, proven cumbersome. People’s professed ecocentric intentions do not always result in ecocentric action. It is therefore essential that authorities experiment with ways that mitigate the disparity between intent and action.

In prior studies, researchers have proposed that communication and incentives are viable intervention schemes. Iyer and Kashyap (2006), for example, experimented by sending information stimuli to sample groups of 633 and 806 students. The researchers’ intention was to
gauge the effects of information containing inspiration, information, and incentives for recycling on spurring students to action. After receiving this information, the students increased their recycling behaviors significantly; the researchers likewise established that their intervention had a lasting effect (Iyer, 2007).

Relevant Theories

Introduction

Many scholars with differing viewpoints have explored environmental behavior for decades to ascertain how to influence and encourage human ecocentrism. Sociologists and psychologists have analyzed different hypotheses, frameworks, and theories to attempt to explain why some people act environmentally and some not. They have also attempted to determine what individuals may perceive as barriers or spurs to pro-environmental behavior. The earliest models for understanding and fostering pro-environmental behavior were linear. Kolmuss and Agyeman (2010) noted that citizens eventually progressed from these early models to more complex attitudes towards the environment, which led them to pro-environmental behavior.

The creators concentrated these early models and frameworks on awareness as a catalyst for action or behavioral change, but they proved ineffective; people’s environmental knowledge

Figure 8. Early Models of Environmental Behavior.
has not usually correlated with pro-environmental behavior. Thus a glaring transitional gap between knowledge transliteration into attitude and behavior introduced a perception of standard cognitive dissonance in environmental theories. Fishbein (1993) noted that previous studies on these relationships—that is, how people’s environmental knowledge leads to their attitudes or behaviors—found relatively low correspondence between attitudes and behaviors, and some theorists proposed eliminating studying attitude as a factor for behavior. Researchers like Ajzen and Fishbein examined other facets that may provide better understandings of why individuals decide to enact environmental behavior, proposing a Theory Of Reasoned Action (TRA) and a Theory of Planned Behavior (TPB).

![Figure 9. Theory of Reasoned Action and Planned Behavior (Azjen & Fishbien, 1986).](image)

In TRA and TPB, the researchers isolated qualifiers for motivation and studied which determinants increased the likelihood of performing a behavior. Thus, the behavior intention, whose precursor is an attitude towards that behavior combined with normative and evaluative beliefs, moderates intention and action.
In their TRA and TPB, Ajzen and Fishbein (1986) seem to have overlooked the essential aspect of the locus of control, a concept Hines introduced in the Model of Responsible Environmental Behavior (MREB). MREB re-emphasized individual mental ability, self-belief, and willingness to undertake independent action. Hines et al. (1986) conducted a metanalysis of 128 pro-environmental studies and found the following pillars/variables of environmental behavior: knowledge of issues; knowledge of action; locus of control; attitudes; verbal commitment; and sense of responsibility.

![Diagram of Predictors of Environmental Behavior](image)

**Figure 10.** Models of Predictors of Environmental Behavior (Hines et al., 1986).

While MREB is more complex and far-reaching than TRA and TPB, it still does not sufficiently explain why some people opt for pro-environmental behavior and some not. Critics,
like Kollmuss and Agyeman (2002) for example, have criticized Hines et al.’s (1986) proposed interrelationship between these variables as weak at best. Kolmuss and Agyeman (2002) furthermore charge that the researchers did not consider altruism and a subset of other pro-social behaviors.

While these theories have gone a long way to explain human behavior towards the environment, this researcher asserts that there is still a practical need for a mechanism that assesses how the relationship between behavior and environmental solutions drives action. The complexity of some of the models may alienate some individuals from adapting them as viable, “real-world” implementations. This researcher proposes that a better theory for this outcome is Information, Motivation, and Behavior Skill (IMBST).

**Information, Motivation, and Behavior Skill Theory**

Information, Motivation, and Behavior Skill Theory (IMBST) is a general sociopsychological concept for understanding and promoting sociopsychological health-related behaviors. The IMBST model is a proven theory that practitioners in the health fields widely use for influencing behaviors, for example in HIV patients. Fisher and Fisher (1992), who first proposed the IMBST model, propose that scholars and authorities can adapt the theory to ascertain, predict, and encourage individuals to behave in certain ways in various areas of studies. In this model, Fisher and Fisher (1992) recognize that there are three constructs—information, motivation, and behavioral skills—necessary to engage individuals in given health behaviors. Seacat and Northrup (2010) borrowed these constructs in their research to understand recycling behavior. Figure 11 below illustrates our proposal to adapt the theory further to review curbside recycling.
First, it is essential to provide the individual with information pertinent to the desired task/behavior, for this kind of knowledge impacts action or behavior. Second, it is important to evaluate individuals’ motivation, including internal and external, to accomplish a certain desired action, task, or behavior. Third, scholars must assess individuals’ behavioral skills, which encompass their intentionality, mental acuity, and willingness to adhere to and perform the tasks. IMBST followers, like Fisher (2003), posit that the extent to which an individual is well informed, motivated to act, and possessed of the skill to perform a specific action, their likelihood of performing said action increases when compared to individuals who are less informed, motivated, or able. In this theory, researchers sought to address the deficiencies of TRA and TPB, and specifically how their followers did not consider the dynamic relationship among the constructs, the validity of prediction of key constructs, and lack of conceptual parsimony among constructs.

**Information**

Iyer and Kashyap (2007) and other IMBST researchers divide the term “information” into communication or knowledge. They note that while successful communication depends on content, medium, and format, the successful knowledge depends on how information prompts
individuals to action, and thus, human behavior. Therefore, recipients of information should propagate declarative and procedural knowledge. Declarative information is easily recalled, while procedural information refers to memorable knowledge skills that the conscious and subconscious absorb for future use. When purveyors of information tailor it correctly to the intended audience, it can generate a successful curbside recycling program. Durdan et al. (1985), for example, note that simple reminders towards action or inaction are most effective when they provide direct and intentional messaging.

**Motivation**

Motivation for recycling is a co-produced mechanism involving a service provider and service receptor. Both are essential to achieve success. Even though curbside recycling is a mandatory service for some cities, whether individuals participate or not is often action is voluntary. City or recycling service provider authorities cannot act on behalf of the household. The voluntary aspect complicates recycling, as no individual may be visibly identified as failing to recycle. Individual incentives are usually more effective than group ones since they are easily quantifiable, and individuals relish and seek them. Harder and Woodard (2007) argue that incentives are more effective with individuals with low initial recycling action.

There are internal and external motivators in recycling. Internal motivators are individuals’ beliefs, values, and attitudes, while external motivators are external agents linked to recycling action, intention, and behaviors. Iyer (2007) argues that societal norms, laws and regulations, and monetary incentives are all external motivators that impact curbside recycling performance. Xu et al. (2018) give a compelling argument for individual external motivation, stating, “Under the circumstance of voluntary provision, a rational agent will contribute nothing
to public goods as she/he can still gain the non-excludible collective benefits at the expense of others’ efforts.”

**Behavior**

Promoters of IMBST like XX and YY stipulate that a well-informed and well-motivated individual can effectively perform conduct if they know it is good and has incentives. The theorists focus on behavioral skills and their efficacy. People may therefore absorb the information on and motivation for recycling to initiate and maintain healthy behavior. According to Fisher (2003), individuals who follow the IMBST model may change their performance based on information and behavior when complicated skills are not required. IMBST theory also stratifies the constructs. IMBST theorists like Fisher posits that well-informed individuals are not necessarily spurred into healthy behavioral actions. In addition, highly motivated individuals are also not singularly spurred into behavioral activity. However, when these constructs are combined, the propensity for individual to change their behavior for the better increases (Fisher & Fisher, 1992). Thus humans often need information and motivation as catalysts to change behaviors.

**Prior and Current Research**

For this study, the researchers attempted to evaluate curbside recycling efficacy by applying the IMBST intervention as borrowed from consumer behavioral research. We produced a randomized metanalysis sample of 36 studies reporting 70 interventions to conclude that social modeling and environmental alteration are the most effective techniques. Table 2, culled from Varotto and Spagnolli’s 2017 study, sets out the different curbside recycling modes and their environmental adjustments, interventions, and efficacy.
Table 2. Varotto and Spagnoli, 2017.

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention Type</th>
<th>Recycling Type</th>
<th>Participants</th>
<th>Outcome Measure/s</th>
<th>Duration</th>
<th>Effectiveness during Intervention</th>
<th>Long-Term Effectiveness</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bowmann et al. (1998)</td>
<td>Informative fliers</td>
<td>Curbside</td>
<td>1500 residents (two experimenta l conditions + control group)</td>
<td>Participation rate; the number of recyclables</td>
<td>Five months</td>
<td>Participation: +3.9% Amount of recyclables: +0.07 bag/ household, wk</td>
<td>Participation: +5.6% Amount of recyclables: +0.07 bag/ household, wk</td>
<td>Hedge’s g = 0.478</td>
</tr>
<tr>
<td>Burn (1991)</td>
<td>Informative leaflets</td>
<td>Curbside</td>
<td>213 households (two experiments and 1 conditions)</td>
<td>Participation rate</td>
<td>Eighteen weeks</td>
<td>Participation rate: +8% with respect to control group</td>
<td>Participation rate: +8% with respect to control group</td>
<td>Hedge’s g = 0.649</td>
</tr>
<tr>
<td>Chong et al. (2015)</td>
<td>Persuasive leaflets (different types of messages)</td>
<td>Curbside</td>
<td>5250 non-recyclers (two experimenta l conditions + control group)</td>
<td>Participation rate; the number of recyclables</td>
<td>One month</td>
<td>No significant differences in the outcome measures after the intervention</td>
<td>Not measured</td>
<td>Not measured</td>
</tr>
<tr>
<td>Chong et al. (2015)</td>
<td>SMS reminders</td>
<td>Curbside</td>
<td>5250 non-recyclers (two experimenta l conditions + control group)</td>
<td>Participation rate; the amount of recyclables</td>
<td>One Month</td>
<td>No significant differences in the outcome measures after the intervention</td>
<td>Not measured</td>
<td>Not measured</td>
</tr>
<tr>
<td>Cotteril et al. (2009)</td>
<td>Door-stepping campaign (oral information)</td>
<td>Curbside</td>
<td>6580 households</td>
<td>Participation rate</td>
<td>Fifteen wks</td>
<td>+5.4% (compared to control group)</td>
<td>+1.7% (measured after 3 mo)</td>
<td>Hedge’s g = 0.223</td>
</tr>
<tr>
<td>Grodzinska-Jurczak et al. (2006)</td>
<td>Door-stepping campaign</td>
<td>Both curbside and drop-off</td>
<td>687 households</td>
<td>Amount of recyclables</td>
<td>Fourteen months</td>
<td>+1.6 tons/mo</td>
<td>+11.5 tons/mo (measured after one year)</td>
<td>Hedge’s g = 0.179</td>
</tr>
<tr>
<td>Hopper and Nielsen (1991)</td>
<td>Informative fliers</td>
<td>Curbside</td>
<td>167 residents (three experimenta l conditions)</td>
<td>Participation rate; self-report</td>
<td>Twenty Four months</td>
<td>+0.55 out of a total of 7 recycling opportunities, with respect to the control group</td>
<td>Not measured</td>
<td>Hedge’s g = 0.450</td>
</tr>
</tbody>
</table>

49
Table 2 (continued)

<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention Type</th>
<th>Recycling Type</th>
<th>Participants</th>
<th>Outcome Measure/s</th>
<th>Duration</th>
<th>Effectiveness during Intervention</th>
<th>Long-Term Effectiveness</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hopper and Nielsen (1991)</td>
<td>Written prompts delivered before each scheduled pickup date</td>
<td>Curbside</td>
<td>167 residents (three experimental conditions)</td>
<td>Participation rate; self-report</td>
<td>Twenty Four months</td>
<td>+1.31 out of a total of 7 recycling opportunities, with respect to the control group</td>
<td>Not measured</td>
<td>Hedge’s g = 0.808</td>
</tr>
<tr>
<td>Lord (1994)</td>
<td>Informati ve door-hangers</td>
<td>Curbside</td>
<td>140 households (two experimental conditions)</td>
<td>Amount of recyclables; self-report</td>
<td>Approximately ten days</td>
<td>Amount of recyclables: +3.93/wk More favorable attitudes toward recycling</td>
<td>Not measured</td>
<td>Hedge’s g = 0.341</td>
</tr>
<tr>
<td>Mee (2005)</td>
<td>Marketing communicate-tions campaign Plea and informative door-hangers</td>
<td>Curbside</td>
<td>46,000 residents</td>
<td>Amount of recyclables</td>
<td>Not specified</td>
<td>17%</td>
<td>+37.3% (measured after 3 years)</td>
<td>Hedge’s g = 0.479</td>
</tr>
<tr>
<td>Schultz, (1999)</td>
<td>Informati ve door-hangers</td>
<td>Curbside</td>
<td>605 residents of single-family dwellings (four experimental conditions + control group)</td>
<td>Amount of recyclables; participation rate; contamination</td>
<td>Four months</td>
<td>No significant differences in the outcome measures after the intervention</td>
<td>No (measured after one mo)</td>
<td>Hedge’s g = 0.070</td>
</tr>
<tr>
<td>White et al. (2011)</td>
<td>Informati ve door-hangers (loss/gain and why/how messages)</td>
<td>Curbside</td>
<td>390 households (four experimental conditions + control group)</td>
<td>Participation rate; the number of recyclables</td>
<td>Approximately Three weeks + follow up after six months</td>
<td>Statistically significant difference in both the outcome measures after the intervention. Differences in effects due to different types of messages</td>
<td>Statistically significant difference with respect to baseline sustained over time (measured after six mos)</td>
<td>Hedge’s g = 0.279</td>
</tr>
<tr>
<td>Willman (2015)</td>
<td>Door-stepping campaign (oral + written information)</td>
<td>Curbside</td>
<td>260 households (two experimental conditions + control group)</td>
<td>Bin adoption; participation rate</td>
<td>Two months</td>
<td>Bin adoption: +40 vs. +2 (control group) No differences in the participation rate</td>
<td>Not measured</td>
<td>Hedge’s g = 0.587</td>
</tr>
</tbody>
</table>
Out of the 14 information and prompt reminder interventions on curbside recycling, four had no significant effect. Five had a substantial impact of more than 5% participation or tons collected, while the rest saw some increase but not substantial enough to warrant intervention-based effects annotation.

All the incentive-based interventions had significant positive consequences—contamination reduced by half while the average participation rate was more than information/prompt-based intervention results. A combined intervention with multiple
intervention techniques had a more comprehensive continuum of positive increase than reminder prompts and even incentive-only prompts. The authors did not measure the post-intervention effectiveness, which we contend is essential. Only seven interventions of 20 attempted to verify long-term effects, with 13 negating the importance of the procedural knowledge quotient of information residual value and concentrating on the declarative knowledge portion.

Research Framework

Conceptual Model Framing

Using the IMBST principles, we anticipate performing a theory-testing experiment on two different curbside recycling programs. We plan to assess information and incentives prompts, and their durability, by assuming that we will succeed in implementing the new system fully.

![Promt Administration Framework](image)

**Variables**
- Independent Variables: Reminder Prompts and Reward Prompts
- Dependent variables: Participation of Household and Recycling tons collected in route

**Figure 12.** Prompt Administration Framework.
Research Questions

RQ1: What is the relative efficacy of prompts in influencing recycling action in single streams systems?

RQ2: How compelling are motivation techniques (i.e., recycling action incentive systems) in enticing residents to recycle?

Units of Analysis

1. Prompt Group: Households (i.e., individual addresses) per routes.
   By “routes” we mean area in the city where the recycling contract administrator picks up recycling on a particular day of the week.

2. Number of tons the recycling company collects per route.

Hypotheses

H1: Participants will find interventions that use reminder prompts catalyzing in increasing recycling in comparison to interventions that use no prompts.

H2: When administrators combine reminder and incentive prompts, there will be a significant increase in households participating in recycling compared to when administrators use only one of these prompts.

H3: Recyclers will stagnate or even reduce their participation and the amount of tons they recycle when the administrators use no prompts or incentives compared to when they do.
Methodology: Longitudinal Quasi Field Experiment

Design

We have designed this study as a nine-week quasi-experimental longitudinal field experiment to test the impact of IMBST on recycling. Two cities in different counties in South Florida that recycle will serve as the experiment sites. We selected these two based on their use of similar, single stream Residential Curbside Recycling Programs (RCRP); single stream means that recyclers put all recycling material put into a single container without sorting. We had nine points of data collection that we separated into three categories (see Exhibit 1 & 2 in Appendix A): 1) Pre-treatment data on Routes/Groups; 2) Treatment data on Routes/Groups; and 3) Post-treatment data on Routes/Groups. We used the recycling outputs from these data groups as the units of analysis as explained above, i.e., the number of households participating in the experiment and the tons of recycling they produced. Due to communication methods available to households, we used two different forms of messaging. In Hollywood, Florida, we employed the already existing email system to residential groups with RFID (Radio-Frequency Identification D) chips on their carts. For Port St Lucie, we used the “call them all” voicemail system, autodialing messages to the phone numbers associated with the households.

We configured and implemented the design configuration because it has four unique advantages over prior similar research. First, unlike Ayers and Kashyap (2007), Cotterill et al., (2009), Harder and Woodard (2007), and White et al. (2011), we used real curbside recycle structures and their routes as a unit of measurement. Second, we focused our experimental design focuses not just on a reminder prompt for one site but a combination of information and incentive, thereby attempting to assess the incentive quotient. Third, we used a longitudinal method, gathering data gathered over nine observation points over nine weeks to ascertain the
persistent effect of any of mediating variables. Fourth, we implemented a post-intervention sustainability assessment. The data from the post-experiment phase will help researchers analyze if continuality of prompt is necessary.

There are certain limitations to our studies that might hinder us. We assessed both areas using prompts; however, in Port St Lucie, we could use only informal prompts and no incentive prompt, because the county’s curbside recycling system design had only informational reminders available. In Hollywood, we used both information and incentive prompts. In Port St Lucie, our measurement was at the route level, since all recycling carts have RFID chips; in Hollywood, however, only a minimal number of carts have RFID chips, and thus we had to measure at group rather than route levels. These limitations notwithstanding, however, by using this design and adapting it to actual field scenarios, pre-existing information, and incentive measures that residents might or might not have been aware of, we were able to extract evidence to conduct a relatively insightful analysis of household behaviors.

**Design Subjects**

**City of Port St Lucie, Florida.** The city has a franchise agreement with Wastepro (the contractor) to haul all household garbage, recyclables, yard clippings, and bulk items. The city’s Neighborhood Services department manages the franchise agreement. Service schedule days are Monday to Saturday. Single stream recycling takes place once a week. Wastepro collects the recycling material and deposits it for processing at the Port St. Lucie Manufacturing and Recycling facility.

**City of Hollywood, Florida.** The city has a franchise agreement with Wastepro (the contractor) to haul only residential trash and recycling. The Environmental Services Division manages the franchise agreement. Service schedule days are Monday to Saturday. Single stream
recycling takes place once a week. The city pays for the contractor’s sanitation service, and residents pay the city for the service monthly via their water bill. The city partners with Wastepro on “New Rewards,” a recycling incentive program.

**Interventions**

We employed two external stimuli: informal prompts and incentive prompts. In Port St Lucie, we sent reminder prompts to the households on the routes. In Hollywood, we sent both reminder and incentive prompts to the groups:

**City of Port St. Lucie.** We used routes 701, 705, 708, 709, and 712. We used the first three-week periods (i.e., three Mondays) to create a baseline; next we send only a reminder prompt (RP) intervention on the fourth to sixth Mondays. Finally, on the seventh to ninth Mondays, we sent no reminder prompts. We also had two control routes for these nine Mondays, to which we sent no RP. All trucks and carts have RFID chips, which automatically recorded the pickup activity.

**City of Hollywood.** Our challenge with Hollywood was that not all carts had chips. We posted RFID chips to individual households to attach to carts, but a majority ignored the instructions. For our experiment, we could thus only incorporate the households with RFID chips on their carts. We divided these households into three groups, which coincidentally had the same intervention schedule as Port St Lucie. Here we sent both RPs and an Incentive Prompts (IPs). We used two measures to decipher recycling action after the end of the intervention: household participation level plus route tons. Since not all carts had RFIDs, we could only measure participation, and we could not use traditional measurement techniques involving
demographical dynamics. Our focus was on the practical understanding of the impact of the intervention on recycling action, despite demographical implications.

Wasterpro, the contractor performing recycling services, observed that most residents in both cities deposited their recycling carts at the curbside the night before scheduled pick-up. Since the recycling trucks workhours were between 7:00 AM and 6:00 PM, service could commence at any section of the route during this period. We sent the RP or IP stimulus to households on Sunday evenings, alerting them to Monday’s pending collection. As stated above, we used voicemails for Port St. Lucie and emails for Hollywood, since these were already the established lines of communication with residents.

We sent the Port St. Lucie message for three weeks, beginning Sunday, April 18th, and ending Sunday, May 2nd, 2021. The voicemail message was as follows, adapted to the relevant date: “Dear Resident, Recycle material pick-up is scheduled for tomorrow, Monday, April 19th, 2021. Please deposit your recycle cart at the curbside by 7:00 AM. Thank You.” We sent two messages to Hollywood, an IP alone, and a combined RP and IP, over the same period as for Port St. Lucie. The IP alone email message follows:

Dear Resident,

Are you aware you are eligible for 25 reward points if you recycle? Registered accounts have received an RFID sticker in the mail to be placed on your recycling cart. Each time you place your recycling cart out for collection, the sticker will be automatically scanned to record your recycling activity. Scans will be uploaded weekly to your account, with each collection earning 25 points that can be redeemed for various rewards. Visit the rewards website www.wasteprorewards.com for registration and all eligible participating local vendors for points discount allocation.

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Note that recyclables include glass bottles and jars; aluminum cans; steel cans (tin cans); empty aerosol cans; drink boxes; milk and juice cartons; aluminum pie plates; aluminum foil; rigid plastic containers; newspapers and inserts; phone books, magazines, and catalogs; paperboard boxes (cereal, cookie boxes, tissue boxes, etc.); cardboard boxes (must be flattened and cut to fit into the bin); brown paper grocery bags; pots, pans, and metal lids; metal toys; cookie sheets; and manual can openers.

Thank you.

The combined RP and IP email that we sent to the participants in Hollywood follows, adapted only for the different dates:

Dear Resident,

Your materials for recycling pickup is scheduled for tomorrow, Monday, April 19th, 2021. Please deposit your recycle cart at the curbside by 7:00 AM.

Are you aware you are eligible for 25 reward points if you recycle? Registered accounts have received an RFID sticker in the mail to be placed on your recycling cart. Each time you place your recycling cart out for collection, the sticker will be automatically scanned to record your recycling activity. Scans will be uploaded weekly to your account, with each collection earning 25 points that can be redeemed for various rewards. Visit the rewards website www.wasteprorewards.com for registration and all eligible participating local vendors for points discount allocation.

Note that recyclables include glass bottles and jars; aluminum cans; steel cans (tin cans); empty aerosol cans; drink boxes; milk and juice cartons; aluminum pie plates; aluminum foil; rigid plastic containers; newspapers and inserts; phone books, magazines, and catalogs; paperboard boxes (cereal, cookie boxes, tissue boxes, etc.); cardboard boxes
(must be flattened and cut to fit into the bin); brown paper grocery bags; pots, pans, and metal lids; metal toys; cookie sheets; and manual can openers.

Thank you.

Results

Sample Profiles

Port St Lucie consisted of five routes—701; 705; 708; 709; and 712—with the following number of households respectively—895; 917; 1141; 1046; and 1046—for a total of 5203 participant households. We used routes 701 and 712 as the control group, applying no RP intervention to them.

We divided the participant households from Hollywood into three groups—Group IP (Incentive Prompt); Group RP (Reminder Prompt); and Group NP (No Prompt)—with the following number of households respectively—387; 103; and 65—for a total number of 555 participant households. Group NP was the control group.

Overview Of Results Analysis

City of Port St. Lucie. We had a total of five routes in Port St. Lucie this experimental study. We included routes 705, 708, and 709 (N = 3) in the experiment and therefore refer to them as “Experimental” throughout this section; we sent voicemail prompts to the households on these routes to remind them of the upcoming recycling pickup (Message R.P.: Port St. Lucie (voicemail)) from weeks 4 to 6 inclusively. Routes 701 and 712 (N = 2) were the Control groups, to which we did not send prompts. We collected data over nine weeks.

Descriptive statistics of participation in Port St. Lucie. In the descriptive statistics below, we show the ratio of households that submitted recycling items for pickup each week.
(i.e., households that participated divided by the total number of households on each route), from week 1 through 9, inclusively.

<table>
<thead>
<tr>
<th>Week</th>
<th>Condition</th>
<th>Mean</th>
<th>SD</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>Control</td>
<td>0.59</td>
<td>0.09</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>0.63</td>
<td>0.10</td>
<td>3</td>
</tr>
<tr>
<td>Week 2</td>
<td>Control</td>
<td>0.63</td>
<td>0.09</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>0.58</td>
<td>0.19</td>
<td>3</td>
</tr>
<tr>
<td>Week 3</td>
<td>Control</td>
<td>0.58</td>
<td>0.06</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>0.60</td>
<td>0.08</td>
<td>3</td>
</tr>
<tr>
<td>Week 4</td>
<td>Control</td>
<td>0.57</td>
<td>0.10</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>0.76</td>
<td>0.09</td>
<td>3</td>
</tr>
<tr>
<td>Week 5</td>
<td>Control</td>
<td>0.61</td>
<td>0.15</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>0.79</td>
<td>0.09</td>
<td>3</td>
</tr>
<tr>
<td>Week 6</td>
<td>Control</td>
<td>0.55</td>
<td>0.06</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>0.79</td>
<td>0.04</td>
<td>3</td>
</tr>
<tr>
<td>Week 7</td>
<td>Control</td>
<td>0.57</td>
<td>0.11</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>0.74</td>
<td>0.06</td>
<td>3</td>
</tr>
<tr>
<td>Week 8</td>
<td>Control</td>
<td>0.52</td>
<td>0.03</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>0.68</td>
<td>0.03</td>
<td>3</td>
</tr>
<tr>
<td>Week 9</td>
<td>Control</td>
<td>0.54</td>
<td>0.13</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Experimental</td>
<td>0.65</td>
<td>0.10</td>
<td>3</td>
</tr>
</tbody>
</table>

**Figure 13.** Descriptive Statistics of Participation by Week in Port St. Lucie.

In Figure 14, we offer a plot that depicts the means of the Experimental and Control groups over the nine weeks. We noted not much difference between the ratios for the first three weeks of the study and, in fact, the lines cross back and forth over one another. After week 4, the first RP week, however, we noted a disparity in the numbers of households taking part. From this data we deduced that the RPs stimulated residents to participate more in the recycling process.
Figure 14. Weekly Descriptive Plot for Port St. Lucie.

Descriptive statistics in tons for Port St. Lucie. In Table 3, we demonstrate how tons varied between the weeks per Experimental or Control status. As noted, 701 and 712 were Control routes. By comparing the means for the Control and Experimental routes, we were able to conclude that the RP stimulus was having an effect.

Between weeks 1 and 3, i.e., before the RPs, the Experimental routes household owners were recycling an average of 4.84 tons. Between weeks 4 and 6, i.e., after the RPs began, they recycled an average of 7.25 tons per week. Between weeks 7 and 9, i.e., after the RPs ceased, the average was 6.18 tons. From these data, we concluded that the RPs had a lasting impact; the impact declined somewhat after we stopped the RPs, but the householders continued to recycle more than they had before we sent any prompts. In the Control routes, the average tons the household owners recycled remained fairly stable: 6.47 tons between weeks 1 and 3; 6.50 tons between weeks 4 and 6; and 6.25 tons between weeks 7 and 9.
Table 3. Descriptive Statistics of Tons by Week for Port St. Lucie.

<table>
<thead>
<tr>
<th></th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
<th>Week 6</th>
<th>Week 7</th>
<th>Week 8</th>
<th>Week 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route 705</td>
<td>6.77</td>
<td>3.80</td>
<td>4.12</td>
<td>6.03</td>
<td>6.73</td>
<td>7.13</td>
<td>6.80</td>
<td>6.81</td>
<td>6.27</td>
</tr>
<tr>
<td>Route 709</td>
<td>3.65</td>
<td>6.01</td>
<td>6.73</td>
<td>8.00</td>
<td>9.58</td>
<td>8.64</td>
<td>7.79</td>
<td>5.92</td>
<td>5.05</td>
</tr>
<tr>
<td>Route 701</td>
<td>5.87</td>
<td>6.11</td>
<td>5.88</td>
<td>5.77</td>
<td>5.64</td>
<td>5.98</td>
<td>6.03</td>
<td>6.14</td>
<td>5.45</td>
</tr>
<tr>
<td>Route 712</td>
<td>6.99</td>
<td>7.03</td>
<td>6.94</td>
<td>6.98</td>
<td>7.00</td>
<td>7.63</td>
<td>7.47</td>
<td>6.35</td>
<td>6.05</td>
</tr>
<tr>
<td>Route 708</td>
<td>4.91</td>
<td>3.12</td>
<td>4.47</td>
<td>6.08</td>
<td>6.71</td>
<td>6.37</td>
<td>6.78</td>
<td>5.57</td>
<td>4.72</td>
</tr>
<tr>
<td>Condition: Control</td>
<td>Week 1 Mean</td>
<td>Week 2 Mean</td>
<td>Week 3 Mean</td>
<td>Week 4 Mean</td>
<td>Week 5 Mean</td>
<td>Week 6 Mean</td>
<td>Week 7 Mean</td>
<td>Week 8 Mean</td>
<td>Week 9 Mean</td>
</tr>
<tr>
<td></td>
<td>6.43</td>
<td>6.57</td>
<td>6.41</td>
<td>6.38</td>
<td>6.32</td>
<td>6.81</td>
<td>6.75</td>
<td>6.25</td>
<td>5.75</td>
</tr>
<tr>
<td>Condition: Experimental</td>
<td>Week 1 Mean</td>
<td>Week 2 Mean</td>
<td>Week 3 Mean</td>
<td>Week 4 Mean</td>
<td>Week 5 Mean</td>
<td>Week 6 Mean</td>
<td>Week 7 Mean</td>
<td>Week 8 Mean</td>
<td>Week 9 Mean</td>
</tr>
<tr>
<td></td>
<td>5.11</td>
<td>4.31</td>
<td>5.11</td>
<td>6.70</td>
<td>7.67</td>
<td>7.38</td>
<td>7.12</td>
<td>6.10</td>
<td>5.32</td>
</tr>
</tbody>
</table>

In Figure 15 below, we plot the means of tons in the Experimental and Control routes. From these statistics we concluded that over time, the tons in Control routes 701 and 712 remained reasonably static, while they fluctuated in the Experimental routes. There we could see that after the RPs began in week 4, the householders increased their recycling by 1.6 tons each week. This trend continues into week 6, i.e., after the RPs ceased, when we start to see a decrease.

Figure 15. Descriptive Plot of Means Ton for Port St. Lucie.
Repeated-measures analysis of variance (ANOVA). We conducted a repeated-measures ANOVA to examine if there were differences between the Experimental and Control groups, and how households reacted to the effects of time based on this status. The results are in the following table.

Table 4. Within-Subjects Effects.

<table>
<thead>
<tr>
<th>Cases</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>p</th>
<th>$\eta^2_p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>0.060</td>
<td>8</td>
<td>0.008</td>
<td>1.889</td>
<td>0.109</td>
<td>0.386</td>
</tr>
<tr>
<td>Time * Condition</td>
<td>0.087</td>
<td>8</td>
<td>0.011</td>
<td>2.725</td>
<td>0.026</td>
<td>0.478</td>
</tr>
<tr>
<td>Residuals</td>
<td>0.095</td>
<td>24</td>
<td>0.004</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We did not notice a significant between-subjects effect based on Experimental or Control status, nor a within-subjects effect for time by itself (this is fine for your study); we did, however, note a significant effect for time* condition: $F(8,24) = 2.75$, $p = 0.026$, $\eta^2_p = 0.478$. We interpret this evidence to mean that the status, i.e., Experimental or Control, had an effect based on time (i.e., the particular week in the study) of household participation. We note this same effect in the descriptive plot of Figure 5 above. (This is good; this is what you were looking for). Mauchly’s W equaled 0.00, which prompted us to use the Huynh-Feldt correction; although the epsilon was 1.00, we derived the same result as we assume we might have obtained through sphericity.

The Port St. Lucie results allow us to support H1, for the household owners increased their recycling participation after the RP intervention. As seen in Figure 14 and Table 3, the people who participated in the Experimental routes (705, 708, and 709) increased from pre-RP to RP weeks by 18%, undoubtedly giving credence to H1. We put the statistics of Figure 14 into a
graphical analysis, which resulted in a semblance of a bell curve for the Experimental routes, with the peaks being treatment days. Our analysis of the Control routes also supports this conclusion, with pre-RP weeks averaging at 56% participation, RP weeks at 58%, and post-RP weeks reducing to 54%; these changes in statistics pale in comparison to the changes in the Experimental routes.

As seen in Table 3, Port St Lucie also lends credence to H3, since there were no significant changes in the amount of collected tons in the control routes. The first set of three weeks averaged 6.47 tons, the second set averaged 6.50 tons, and the last set 6.25 tons. Thus, we may conclude that the lack of RPs effected no change on the Control routes (see Figure 16).

Table 5. Participation Percentages for Hollywood.

<table>
<thead>
<tr>
<th>Condition: Control</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
<th>Week 6</th>
<th>Week 7</th>
<th>Week 8</th>
<th>Week 9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>47%</td>
<td>63%</td>
<td>58%</td>
<td>57%</td>
<td>61%</td>
<td>55%</td>
<td>57%</td>
<td>52%</td>
<td>54%</td>
</tr>
<tr>
<td>Condition: Experimental</td>
<td>63%</td>
<td>58%</td>
<td>60%</td>
<td>76%</td>
<td>79%</td>
<td>79%</td>
<td>74%</td>
<td>68%</td>
<td>65%</td>
</tr>
</tbody>
</table>

Figure 16. Port St. Lucie Recycling Results Statistics.
City of Hollywood, Florida. We designated three groupings for Hollywood for this study. We sent both RP and IP prompts to the first group; only the IP prompt to second group; and no prompts (NP) to the third and final group. Since we had a single group for each criterion, we were not able to calculate means and averages, and we assessed the data instead through participation percentages, i.e., the percentage of total households that participated within each group. We found the percentile measure appropriate also due to the disparity in total households per group: 389 in the RP and IP group; 104 in the IP group; and 65 in the NP group.


<table>
<thead>
<tr>
<th>Participation Per Week</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
<th>Week 6</th>
<th>Week 7</th>
<th>Week 8</th>
<th>Week 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group RP&amp;IP</td>
<td>218</td>
<td>247</td>
<td>227</td>
<td>262</td>
<td>254</td>
<td>264</td>
<td>256</td>
<td>258</td>
<td>250</td>
</tr>
<tr>
<td>Group IP</td>
<td>17</td>
<td>21</td>
<td>16</td>
<td>38</td>
<td>52</td>
<td>48</td>
<td>75</td>
<td>78</td>
<td>64</td>
</tr>
<tr>
<td>Group NP</td>
<td>37</td>
<td>33</td>
<td>35</td>
<td>33</td>
<td>39</td>
<td>28</td>
<td>40</td>
<td>45</td>
<td>41</td>
</tr>
</tbody>
</table>

| Participation Three-weekly Average | | | | | | | | | |
|-----------------------------------| | | | | | | | | |
| Group RP&IP                       | 0.56 | 0.64 | 0.59 | 0.68 | 0.66 | 0.68 | 0.66 | 0.67 | 0.65 |
| Group IP                          | 0.17 | 0.20 | 0.16 | 0.37 | 0.50 | 0.47 | 0.73 | 0.76 | 0.62 |
| Group NP                          | 0.57 | 0.51 | 0.54 | 0.51 | 0.60 | 0.43 | 0.62 | 0.69 | 0.63 |

We can report that participation more than doubled for the IP intervention group during week 4, which is when we commenced it, while the participation in the RP and IP group in the same week was only 9%. In comparison, we saw a 3% drop in the NP group. Plotting these changes provided us with a better picture and assessment of the effects. The data in Figure 6 below allows us to deduce that intervention has an impact. Still, when we considered the NP group trends, we realized that interventions might not be the only factors impacting participation;
the participants in the NP group increased their participation percentages despite receiving no prompts.

Figure 17. Weekly Descriptive Plot of Recycling Participation in Hollywood, Florida.

From the data in Figure 17 above, we may see a relatively stable participation percentage in all three groups during the first three weeks, i.e., before we implemented any prompts. During weeks 4–6, after we deployed the prompts, households within the IP group increased their pattern dramatically by 27%. During the same period, the participation within group RP and IP increased by 7%, while it decreased by 3% in the NP group.

In post-treatment weeks 7–9, the participation within the RP and IP group remained consistent with that of weeks 4–6, with only 1% of difference, while the participation within the IP group increased by 26%. This percentage is very close to the initial 27%, i.e., the increase that occurred in this group during weeks 4–6. The households participating in the NP group also increased by 13% during weeks 7–9, for which we could not determine a cause per our study.

The results we derived from Hollywood led to our inability to confirm H2. As we saw in Table 5, the participation of households with the combined RP and IP group averaged 60% pre-intervention; 67% during intervention; and 66% post-intervention. These percentages were less
than those of the households within the single prompt group, i.e., the IP group, where the average of households participating increased by 28% once we began the intervention, and post intervention remained at 53% more than pre-intervention. The participation of the NP group allowed us to meet our H3 assumption for the first six weeks of data; however, on week 7 the percentage of households participating spiked by 11% compared to the average of weeks 1–3.

Discussion

We were surprised that the households in the combined IP and RP group in Hollywood participated less than those within the IP alone group; we likewise found unexpected the fact that the individuals within the NP group unexpectedly increased participation in week 9. Despite these anomalies, we hold that our results also overarchingly confirm the efficacy of reminders as a potent tool for moderating recycling behavior, a face we see in the Experimental and IP groups in Port St. Lucie and Hollywood, respectively. The households that received the prompt reminders in Port. St Lucie both changed their recycling behaviors and showed promise of sustaining this change even after the intervention, i.e., weeks 7–9. Baseline data participation, when compared to post-treatment data, shows a 9% increase in participation. We, however, acknowledge that while post-intervention data remained high without prompts in two of the three Experimental routes by week 9, it fell to below the level of week 1 in the third route.

In Hollywood, our assumption that household owners would react more to a combination of reminders and incentives was challenged; instead, they reacted more to the singular IP intervention, and their change remained comparatively higher post-intervention. Prior researchers have noted the efficacy and durability of incentive prompts; for example, Harder and Woodard (2007) noted an increase of 21% in participation. In terms of the surprising data in Hollywood, we theorized that one reason individuals in Hollywood did not find the reminder
prompts effective might be that similar efforts had been ongoing for ten years, rendering residents well aware of schedules. We theorized that because our incentives prompts were unexpected and novel, residents reacted enthusiastically to them and increased their recycling.

When looking at the disparity in results between the two cities, we also considered the mode of communication. We used voicemail in Port St. Lucie and email in Hollywood, since these were the communication tools already in place. Emails allowed us to create more formal content than for voicemail, which perhaps made the latter more accessible (Duthler, 2017). This fact might help us to explain why while both the residents in both Port St. Lucie and Hollywood increased their participation by similar percentages (18% and 17%, respectively) for their intervention weeks for experimental routes in the post-treatment weeks, Hollywood residents’ increased from the baseline by 29%, while those in Port St. Lucie’s by 9%. This comparison might be skewed due to the fact that we added incentives to the Hollywood reminders but not Port St. Lucie’s. Future researchers may wish to focus on the role incentives play in increasing participant durability when it comes to recycling action.

Conclusion

Our research had modest expectations; we did not seek to radically change recycling behavior trends but to assess whether there were opportunities for improvement. The study lasted only nine weeks, while habit-formation typically takes 18 to 254 days, as behavioral health psychology researcher Phillipa Lilly posited (Lilly et al., 2010). The process depends on the individual, the behavior in question, and the particular circumstances. As we only had nine weeks of interface in our study, we wished to investigate how certain triggers may prompt behavioral change, leaving it to researchers after us to consider long term implications. Our research analysis provided these insights.
Figure 18. Estimated Total Collect Tonnage of Single-Family Curbside Materials.

Note. Taken from The Recycling Partnership (2020).

In reiterating the importance of participating in residential curbside recycling, the 2020 State of Curbside Recycling report emphasized that “capture” behaviors are critical for curbside recycling programs’ success (Recycling Partnership, 2020). As evidenced in Figure 7, the national participation rate of 61.50% is similar to the average baseline pre-intervention participation in Port St. Lucie, i.e., 60%. During the intervention, however, Port St. Lucie residents surpassed average national involvement by 18%. Noted too is as a percentage of all materials generated recycling rate is only 32%.

Incentives, per the IMBST model, are essential in modifying human health behavior. Yet we discovered that when we offered IP and RP combined, or indeed NP, we had less dramatic and shorter term effectiveness than when we offered IP alone. Residents in the IP group increased their recycling by 27% over the baseline, while those in the IP and RP improved by only 7%. Overall, when we evaluated the complete intervention period, and all routes and groups in both Port St. Lucie and Hollywood, we noted that the residents who received the IP and RP
combination did surpass the national average, allowing us to validate the main IBMST assumptions.

As Americans progressively come to terms with global warming, we hope that we will take note of this research, and especially of its finding that curbside recycling is a simple and available tool that allows us to act responsibly towards sustaining the planet for future generations. Our findings also have practical significance for local authorities administering curbside programs. In our study we demonstrated that a well-run reminder prompt system can successfully increase householders’ participation over time, as indicated in Port St. Lucie’s $P = 0.026$ rise over the control group. With the average cost of landfill disposal in Florida being $56.51$ per ton, transposing trash into recycling material will furthermore allow citizens to contribute enormous savings to municipalities (Redling, 2021). Academics may find useful our practical approach—which includes obtaining surveys, analyzing perceptions, and starting from assumptions—to provide confirmatory platforms; we sought to apply theories to real-life circumstances, despite the many moderating influences of demographics. Academics might also appreciate the fact that we have been able to adapt and modify a behavioral health theory to apply to environmental conduct.

**References**


Iyer, E. S. & Kashyap, R. K. (2007). Consumer recycling: Role of incentives, information, and


Appendix A: Design of Time Series Experiments

Figure 19A. City of Port St. Lucie Multiple Time Series Quasi Experiment Design.

Treatment communication to Residents: Voicemail
Prompt: Message RP

Figure 19A. City of Port St. Lucie Multiple Time Series Quasi Experiment Design.
**Treatment communication to Residents: Email**

Prompt: Message RP  
Incentive: Message IP  
Prompt & Incentive (message RP&IP)  
No Prompt: NP

**Figure 20A.** City of Hollywood Interrupted Multiple Time Series Quasi Experiment Design.
CHAPTER THREE:
ARTICLE 3 – THE RECYCLE CONTAMINATION CONUNDRUM

Introduction

Recycling enables the collection, processing, and remanufacturing of collected material. Contamination is a significant hindrance to this preferred regeneration loop and occurs when materials are sorted into the wrong recycling bin (placing a glass bottle into a mixed paper recycling bin, for example) or placing materials ineligible per material recovery facility (MRF) standards in recycling bins (Rachelson, 2017). Even though definitions vary, we could perhaps agree that contamination is the percentage of recycling material inbound to the MRF that ends in the landfill (Townsend, 2020). In developed nations, aggregate recycling rates have plateaued in recent years.

In contrast, the contamination rate of recycling has increased due to consumers’ incorrectly recycling ineligible items (Catlin et al., 2020). A 2019 Recycling Partnership survey found that the U. S. had an average contamination rate of 16%, thereby further dwindling the already low recycling rate of only 35.2% in 2017 (Environmental Protection Agency [EPA], 2019). However, Waste Management, the biggest provider of recycling services in the United States, posited that the actual contamination rate is 25% (Bell, 2018), which was supported by the study done for all Florida MRF contamination rates. The study showed a single-stream contamination rate of 27% and a dual-stream MRF contamination of 18%, with a total composite average of 25%. Common contaminants include but are not limited to soft plastics, E-waste, used
tissues or paper towels, food waste, crockery, Pyrex, textiles, garden waste, and bagged recyclables. Despite the prevalence of contaminants, only 35% of communities are aware of the inbound contamination rate of their waste streams (The Recycling Partnership, 2020).

Residential recycling faces a conundrum when it comes to choosing whether to implement a residential recycling system. With dual and single-stream options available, contamination should be a critical element to consider. In a single stream, all recycling materials are deposited in a single cart or bin, whereas in a dual system, materials are separated based on MRF and municipality requirements. Thus, preliminary separation starts from the source in dual-stream, while it begins at the MRF site in single-stream. Single stream often requires a higher level of capital investment since the quality of materials coming from its collection is less than dual-stream. However, because it requires two containers and a dual-compartment truck, the collection cost of the dual-stream is higher (Lakhan, 2015).

In a comprehensive study over ten years, 223 municipalities that implement single-stream systems were found to have higher material-management costs and divert materials more(?) than dual-stream systems (Lakhan, 2015). Dual-stream involves additional process action since the recycler must be cognizant of what to put in the separate bins/carts, so the act of recycling must be more intentional than in a single stream system. While both systems will have contaminants, dual-stream has been proven to be a better option even though it requires more effort, which can hinder participation. Thus, in assessing the contamination ratio of the recycling system in place, decisionmakers are challenged in balancing participation and higher quality recycling output.

**Reason for Recycle Contamination**

The varying and myriad reasons for contaminants are summarized below.
Overinclusive Recycling

Overinclusive recycling occurs when individuals anticipate a more positive feeling towards recycling and a more negative emotion for trash. One factor is the labeling of recycling receptacles in public settings (parks, airports, etc.) that nudge people toward (overinclusive) recycling by amplifying their anticipated emotions from trash and recycling. Bin such as “Save the Earth” “Do not Destroy the Earth” could induce a more negative emotion associated with trash, thereby increasing the likelihood that a recycling item may be disposed of in the recycle cart instead of the garbage cart (Catlin et al., 2021).

Design of Recycling Program

Waste Management, the most significant residential recycler in the United States, stated the contamination has increased over the years due to the switch of residential recycling programs from dual to single-stream and increasingly complex packaging materials (Robinson, 2016).

Know-How

Most Americans want to recycle, believing that recycling provides an opportunity for them to be responsible caretakers of the Earth. However, it can be difficult for consumers to understand what materials can be recycled, how materials can be recycled, and where to recycle different materials. This confusion often leads to placing recyclables in the trash or throwing trash in the recycling bin, contaminating the recycling stream (EPA, 2019).

Stakeholder Dysfunction

There is inadequate and sometimes no communication between specific stakeholders. For example, manufacturers of new materials and products and the recycling industry need to
understand product-packaging composition and recyclability further. Without communication, ascertainment recyclability can lead to contamination (EPA, 2019). Therefore, the recycling infrastructure has not kept pace with the waste stream. An item might be recyclable, but the MRF does not have the capabilities of sorting and reconfiguring its reuse. Communication between the manufacturers of new materials and products and the recycling industry needs to be enhanced to prepare for and optimally manage the recycling of new materials (EPA, 2019).

**Domestic and International Markets**

The recycling industry faced a momentous shift when the Chinese law Operation National Sword banned 24 types of waste material and other contaminated recycling-material imports while setting a stricter standard for contamination levels. Before this, China was an importer of 70% of U. S. recycling material (Katz, 2019). The U. S., therefore, was not equipped to deal with this radical and sudden change in Chinese policies. As the U. S. began to adapt by recycling its own materials, more and more tons of waste were landfilled due to poor quality and cost (Moreton 2020). Thus, material categorization and certification changes caused recyclables formally labeled clean to be labeled contaminated.

**Solutions to Contamination**

Contamination challenges are surmountable if a clear action plan and implementation strategy could be reoccurring due to the human element in its production and regeneration. Additionally, the circularity of recycling within stakeholders must be examined to identify where the challenges may arise and address them at the point of conception.
Figure 21. Value in the Flow of Materials in the Curbside System Report.

*Note: The source is the State of Curbside Recycling Report (2020)*

Figure 19 demonstrates that the seamless flow of information and management of somewhat independent quotients will be daunting. Information flow seems more feasible for the core stakeholders: producers, consumers (residential curbside collection), and processors (MRF, paper mills, and plastic reclaimers). The following a proposed steps municipalities and recyclers should consider in the contamination reduction plans.

**Tagging**

Tagging and abandonment of carts with unsanctioned recycled materials by drivers in their routes. In its recycling operations at Siler City, North Carolina, and Eglin, Illinois, Waste Management Corporation reduced contamination by 20% and 15%, respectively, when they
combined tagging with education and Facebook ads (Robinson, 2016). However, it is necessary to recognize that tagging is a time-consuming exercise that usually entails additional personnel.

**Education**

Per the Florida Department of Environmental Protection, education is one of the most effective solutions to contamination avoidance. Collectors (drivers of recycling trucks) and residents must be constantly educated and reminded of recyclable materials. For example, in 2019, Sarasota, Florida, switched from dual-stream bins system to closed lid single stream carts, despite the assumption single stream being more prone to contamination. With the recycling education from grants made available by The Recycling Partnership, Sarasota was able to achieve 85% accuracy material placed in the recycling cart in addition to a 10 % increase in participation (The Recycling Partnership, 2020).

**Packaging**

This is contamination prevention from the source. A clear and concise description of packages gives the residential household knowledge about what they are putting in a recycling bin and whether it is allowed or not. Plastic bags should be strongly discouraged. Most MRFs avoid plastics due to their post-use worthlessness since recycling material is higher than cost; they are also a source of constant MRF-machinery breakdown, as seen in Exhibit 3 (Waste Management 2018).

**Anaerobic Digestion**

Integrate the use of digester for recycling contaminated with food and food-related matter. Rather than taking contamination by food waste or trash to landfill as contamination, municipalities should explore digester use.
Recycling Tracking and Analytics

Continuous waste tracking will enable the identification of real-time defaulters of recycling material output and give subsequent real-time feedback to customers (Robinson, 2016). Analyses of the recycling stream of each route will also provide municipalities with information about which materials their residents produce the most and the most significant contaminant.

Constant Communication

Municipalities should label the recycle cart or bins with clear instructions. Labels are the first communication tool on the recycling bin/cart due. Labels on containers should include what can be recycled and what cannot (Rachelson, 2017). Other communication tools include direct mailers, inserts, Facebook, radio, and TV ads.

Conclusion

There is not a single solution for recycling contamination. Recycling contamination solutions are always used in concert with each other, for example labeling and education in Sarasota (The Recycling Partnership, 2020). Simplifying the messaging process is essential since complicated communication, educational tools, or directions only muddle the process. Furthermore, human dynamics and demographics play a role and make constant adjustment to changes paramount. Analyzing the municipality’s current population age, race, political leanings, education levels, and income levels is essential in choosing the medium, type, and intensity of contamination deterrents.
References


Environmental Protection Agency (2019b). *The U. S. recycling system: Current challenges facing the system.* https://www.epa.gov/americarecycles/us-recycling-system#CurrentChallenges


Figure 22A. MFR Facility Plastic Issues.

Note: The source is Waste Management Media Room.